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POWER

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The Power Review

ENGROSSED as the busy engineer is in the day's work, hemmed in by an often narrow environment, it is difficult for him to appreciate the trend of progress and the rate at which it is being made.

This issue of *Power* is devoted to a survey of its field, reviewing recent development and recording the present status.

Since this was last done in these columns, the movement has been rather in the direction of a more studied application and use of materials, apparatus and appliances already available than in the creation of new things or increase in magnitude of the old.

There have been refinement and improvement in available apparatus as manufacturers have met the needs and overcome the difficulties of the user and have sensed the potentialities and limitations of their wares.

Designers and users are becoming increasingly aware of the possibilities of the newer facilities and their interrelations; and recent practice has been more in the nature of consolidating and co-ordinating gains than of further advances into the untried.

In the following columns leading authorities discuss the latest practices in coal burning by both the stoker and the pulverizing methods; the boiler with its recent increase in pressures, temperature and capacities, involving furnace design and water walls; the essentials of condenser design; the internal-combustion engine; elevators; process steam and the automatic bleeding of reciprocating engines; recent improvements in refrigeration, heating and ventilating practice.

The reader who absorbs the contents of this issue will be well informed on the present principal aspects of power-plant engineering and well equipped for deductions as to future developments.

F. R. Low

What a Review of the Pas in the Power Fie

NOW AND THEN it is good to stop in one's tracks and look about a bit, to see where one is; and to look back along the path that has been traversed, to profit by missteps and needless detours in laying a further course more wisely. In this issue, *Power* endeavors to present a group of summaries showing where power engineering stands today, as things appear to leaders in various activities.

. . . In the field of boiler furnace design and fuel handling and feeding, there is perhaps nothing strictly new, but there is evidence everywhere of progressive improvement of equipment and more intelligent application in design and control in operation. It is probably fair to say that the struggle between stokers and pulverized coal that raged a few years ago has abated somewhat. Sane men everywhere recognize that each method has its merits, and that the two are allies in the common battle to keep down the cost of power. The most vigorous arguments today are between the proponents of various types of water-cooled furnace walls and of various designs of air preheaters, and the like. Doubtless, as time gives us all better perspective, we shall come to see that all these advocates are working together in the same cause, traveling by different paths but in the same direction.

. . . The possibility of extracting steam from a reciprocating engine at pressures above the exhaust opens up a broad field of applications in industries that need process steam and have power requirements that do not lend themselves readily to steam turbine drive. The story is told of a modern process steam plant, equipped with up-to-the-minute apparatus, that should serve as a model for many a manufacturer who is spending more than he should and condemning his engineers to worry along with equipment that has long since outlived its usefulness.

. . . The statistical pages by the editors open up a view of the field from the business angle that should interest every wide-awake engineer. And the explanation of the meaning of certain terms in the United States Census reports is of paramount importance to all who use these figures as a basis for estimating the volume of business.

. . . Heating and ventilation is a part of the responsibility of the power executive in many establishments, and it is a field in which there seems to be much mystery and rule of thumb. *Power* is helping to dispel the mist and supplant the thumb by publishing informative articles discussing current developments in that field.

Past Twelve Months Field Reveals

. . . The oil engine is meeting the present-day demand for cheaper power through the building of engines to run at higher speed, with less bulk and lower cost. And this same development opens up new uses for the oil engine in competition with other internal-combustion engines, as, for example, in the power plants of automotive trucks.

. . . In the field of refrigeration *Power* has long given attention to the technical side. In this issue there appears a discussion of the business aspects of ice making that is much needed in this day of competition from the household refrigerating machine. The technical side of the business is represented by a discussion of the design of evaporating coils.

. . . Notwithstanding the rapid developments made in steam-plant economy and the low price for fuels, water-power developments continue to supply about 36 per cent of the power generated in central stations. How the present competition between steam and hydro-electric plants will affect this figure it is too early to predict.

. . . As a conservation proposition it is desirable that water power should be developed wherever economically possible. If the rate at which these developments have been made during the last eight years is to continue, it will be necessary that changes in designs be made which will allow development of sites at lower costs than for some of the conventional designs.

. . . Already there are evidences of such changes in the form of higher speed units; plants in which the superstructure has been eliminated with generators designed for out-of-door operation; and elimination of the conventional type of switchboards and busbar galleys so that all the equipment can be installed within the limits of the generator room. Improvements in the design and control of concrete structures, better planned construction programs to reduce the time of construction, and the use of welded structures offer possibilities of making water-power developments more attractive.

AS ONE reviews the contents of this issue, he is struck with the fact that the field of power generation and transmission and application is alive. Like a living organism, though not often subject to cataclysmic changes, such as the metamorphosis of the butterfly, it has a strong healthy growth. This promises well for the future.

CENTRAL STATION PRACTICE *Shows Higher Efficiencies*

By FRANK S. CLARK

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DURING the last few years remarkable advances have been made in improving the efficiencies of steam power stations, and the bogey of "a pound of coal per kilowatt-hour" is being equaled and bettered in more than one modern station. These advances have been made possible by the increases in steam pressures and temperatures, by bettering the efficiencies of the various pieces of equipment making up a power station, by selection of the proper type of equipment for each process and by the proper co-ordinating of the equipment into an efficiently working whole. Also, being given an inherently more efficient layout, the operating engineers have come through with their part, and the results have been closely approximating the calculated theoretical efficiencies.

The efficiency of a steam power station can be divided into two main parts: (1) Of the boiler room or the efficiency of steam generation, and (2) of the turbine room or the efficiency of steam utilization.

Boiler-room efficiency is divided into two parts: (a) Combustion of the fuel and the transferring of its heat into the gases of combustion, and (b) absorption of the heat of the gases by the working fluid (water) and the production of steam. In addition, there may be the further extraction of heat from the gases of combustion by means of economizers or air preheaters with a consequent increase in efficiency.

Turbine-room efficiency is divided into two parts: (c) The utilization of the heat energy in the steam in the production of mechanical energy by its passage through the prime mover, and (d) the conversion of mechanical into electrical energy by the prime mover.

Coal is the fuel most generally burned under boilers, the use of oil, gas and other special fuels being limited to special cases and a comparatively few localities. The chief sources of loss in combustion efficiency are unburned carbon and improper supply of air for combustion. These losses vary, of course, with the rate of combustion and the manner in which the fuel is burned. With a good grade of West Virginia coal burned on a modern stoker, manufactuers are willing to guarantee that the combustible in the ash will not exceed 6 per cent when operating at its most efficient point. This is much less than half what it would be with older types of stokers in commercial operation; with the average Eastern coal the gain in over-all stoker efficiency is rarely less than 1 per cent and may easily reach 2 per cent.

The use of clinker grinders and a deep clinker pit in which the combustion is completed have been responsible for a great part of this improvement. Improvements in coal feed onto and throughout the length of the stoker, changes in tuyere design permitting better admission of air to the fuel bed, the use of preheated air for combustion and automatic combustion control have contributed toward decreasing the carbon loss and the percentage of excess air in the flue gases.

The use of pulverized coal is growing rapidly. A high temperature of preheated air can be used with advantage and safety. The older method of vertical firing of the pulverized fuel with long flame travel and little turbulence of combustion is being displaced by horizontal firing with rapid mixing of air and fuel, resulting in turbulent combustion and short flame travel with consequent better control of excess air. Methods of pulverizing the coal are being improved, and also the feeding of coal to the burners, resulting in more uniform fineness of coal and rate of feeding.

As to the absorption of the heat in the gases, this is a question of how far it proves economical to go in the utilization of this heat. Boiler design is being studied with a view toward making the most advantageous disposition of its heat-absorbing surfaces over and around the furnace and in the path of the gases. Design and location of superheaters are requiring more careful study as the maximum safe temperature of the steam is now about 750 deg. F. Radiant type superheaters are being used more generally, either by themselves or in series with the ordinary convection type.

Economizers are still used for heating the feed water before entering the boiler, but they are giving place to or being used in conjunction with air preheaters as a means of absorbing heat from the flue gases after they leave the boiler. The preheating of the air for combustion, besides saving additional heat from the flue gases, adds to the efficiency of combustion itself. It promotes more rapid combustion and also leaves a wider range of temperature for heating of the feed water by means of "bled" steam, which has done some work in passing part way through the main prime mover.

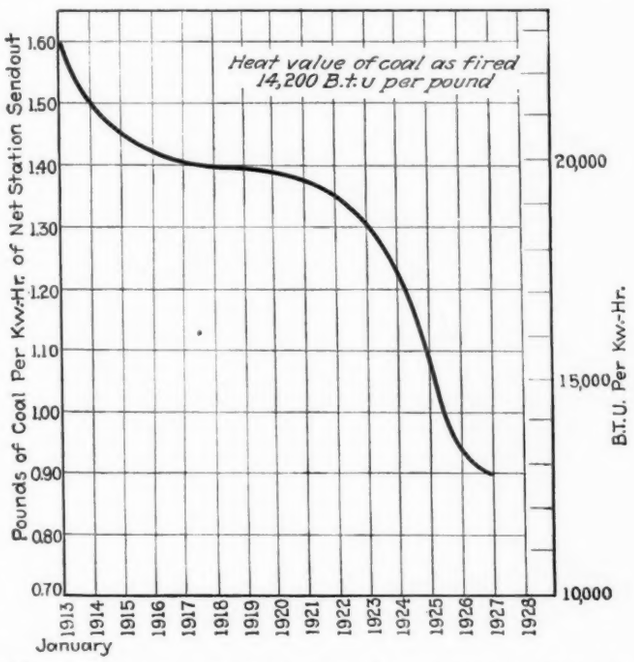
The development of equipment for the control of combustion has been a further means of improving boiler-room efficiency. This equipment regulates the fuel burned, the air for combustion and the draft in proportion to the demand for steam, making adjustments for changing conditions and maintaining the proper relations between the three throughout the range of operation.

In the turbine room we find a number of factors that have contributed to the efficiency of utilization of the energy in the steam. Chief among these are:

1. Increase in steam pressure and temperature.
2. Use of electric drive for station auxiliaries and bleeding of steam from the main unit for feed-water heating.
3. Reheating of the steam after it has passed part way through the main unit.

Steam pressures have increased from 200 lb. per sq.in., used fifteen years ago, to 1,400 lb. per sq.in., which is in successful operation in two modern central stations and contemplated for several more now being designed. A temperature of 750 deg. F. is considered the maximum safe limit which is imposed by the physical qualities of the metals at present available for pipe, valves, fittings and parts of the superheater and main unit subjected to the high temperature.

The adoption of electric drive for the station auxiliaries, the current being generated by the main unit, uses power that has been produced most efficiently and results in a saving over the former method of drive by individual small turbines. For heating the feed water steam is now "bled" from one or more points on the main unit, three or four being the present usual numbers. The steam thus "bled" has given up some of its energy to produce electric power, and the remainder, including the latent heat, is all recovered through the medium of the heated feed water.



The performance of typical stations plotted against the date of their initial operation shows large gains in recent years

Closer attention has been given to the design of turbine generators, which has resulted in improved efficiency. There is a tendency toward larger capacities at the higher speeds. Better material for blading has permitted the use of longer blades with a consequent decrease in leaving losses from the last wheel. The longer blades are being made with warped surfaces to increase their efficiency. Clearances have been reduced, thus decreasing leakage losses. Exhaust casings have been designed to give more uniform diffusion in the exhaust space to prevent "backing up" of the steam and utilize better the exit velocity from the blades. There is an apparent trend toward combining the impulse and reaction principles in the same turbine, utilizing each where it is best suited. Large units are being "compounded," using two or more cylinders either in tandem on the same shaft with one generator or cross-compounded with a generator on each shaft. This gives greater latitude in design, permitting the low-pressure element to be "double flow," and in case of the cross-compound units permits a different speed to be used with each element if desirable. Bearing losses have been cut in half. Better design of cooling air passages in generators has diminished the electrical losses and decreased the power required for circulating the cooling air. The use of external fans has permitted the construction of much larger generators.

The result of the developments given has been a remarkable bettering of the performance of the modern steam station. The curve in the figure shows how much this has amounted to and how rapid has been the improvement in the last six years. To say how much each development has contributed toward this improvement would be a difficult task. Dividing between the efficiency of steam generation and steam utilization, the following figures may be considered reasonable.

For a station of 60,000-kw. main turbine-generators, each with 3,000-kw. auxiliary generator, operating at 400 lb. pressure and 725 deg. F. temperature and at the most efficient loads, the heat utilization, or turbine-room efficiency, would be at a rate of about 10,750 B.t.u. per gross kilowatt-hour generated, or 11,270 B.t.u. per net kilowatt-hour. This corresponds to a thermal efficiency of 31.7 total and 30.3 per cent net. The boiler-room or heat-generating efficiency can be made very high and depends on how far it is economical to go. A sustained efficiency of 85 per cent is not too high a figure in a modern boiler plant. Based on this and allowing an additional one per cent for plant losses, the over-all efficiency becomes 12,845 B.t.u. per gross kilowatt-hour and 13,416 B.t.u. per net kilowatt-hour. If 1,200-lb. pressure turbines were superimposed on the 60,000-kw. units, about 20,000 kw. would be added for a 60,000-kw. unit and a 4,000-kw. auxiliary turbine would be required. On this basis the turbine-room efficiency would be about 9,355 B.t.u. per gross kilowatt-hour and 10,060 B.t.u. per net kilowatt-hour, corresponding to thermal efficiencies of 36.6 and 33.9 per cent. The over-all plant efficiency then becomes 11,150 B.t.u. gross and 12,000 B.t.u. net.

While power-station efficiency has increased rapidly in the last few years, we are reaching the point where the curve is becoming less steep. This is caused by the fact that possibility of large gains is becoming less, and those that are possible are more expensive to obtain. The chief one remaining is from increased steam temperature, and research is being carried out actively to obtain materials that will withstand temperatures of 1,000 deg. F. and upward.

MODERN DEVELOPMENTS

Make Condenser Surface More Effective

By R. H. ANDREWS
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AFTER a period of relative stagnation, during which little progress was discernible except in the development of air-removal apparatus, surface-condenser design has entered into a period of rapid growth, and the many new designs recently brought out indicate far-reaching changes affecting the fundamental conceptions of condensation.

Although the surface condenser is today one of the most important and most costly items of the power plant, it is perhaps the only element, of all the modern equipment entering into the production of power from fuel or water, in which the slope of the efficiency-capacity curve is negative, that is, "downward." In other words, whereas, steam and water turbines, boilers, pumps, generators, transformers, etc. are more efficient in large than in small units, the opposite is true of the surface condenser—the larger the unit the worse its performance, whether measured in terms of B.t.u. transferred per square foot per hour per degree temperature difference, or in percentage of maximum vacuum theoretically attainable with a given amount of condensing surface per kilowatt, and given cooling-water temperatures.

This article on the first five condenser units installed at Gennevilliers Station, Paris, France, discusses recent developments in design.

While this is manifestly an undesirable situation and a challenge to research, its importance should not be exaggerated. The all-important condition is that it be possible to produce, at reasonable cost, a high vacuum for all commercial sizes of turbines; and this condition has been fulfilled. Other requirements in the progress of condensation are:

To perfect the design of the surface condenser, so as to secure the same performance with a lower first cost, by a more efficient utilization of the condensing surface.

To reduce the evil effects of fouling of the tubes.

The second condition is by far the most important. Many central stations, whose circulating water contains large amounts of mud and silt, operate on average vacuum conditions below the manufacturer's guarantees, because they cannot afford to keep their condensers clean.

In the line of a more efficient utilization of condensing surface much work has already been done and excellent results attained, both in the United States and in Europe. In the line of prevention of fouling some progress has been achieved, but much remains to be done.

Before taking up the latest French contributions to the problem of condensation, a brief digression on certain experimental facts and theories involved will be useful.

In any condenser the most efficient part of the condensing surface is that which the steam strikes *first*. This has been proved experimentally by many investigators.

Any condensing surface added *in series* with that receiving the first impact of the steam necessarily works at lower efficiency, because of the increase in air concentration and because of flooding of the condensing surface.

In many tube layouts found in practice today, and in practically all older condensers, the tubes are so set that the condensate from the upper tubes of the bank drains directly onto the surface of all the tubes located vertically beneath them. This forms a film of water that insulates the metal surface more or less completely from the steam to be condensed. Water being almost a non-conductor of heat, the only way the energy content of the steam can be transferred to the metal surface of the tubes is by the medium of convection currents set up within the thickness of the film. The evils of flooding of the condensing surface have been known and studied ever since the surface condenser came into general use.

Furthermore, the air mixed with the steam tends to accumulate on the surface of the tubes in the form of an air film that acts as an added obstacle to heat flow. It is, therefore, highly advisable that as much as possible of the condensing surface be exposed to the direct impact of the steam, when the latter's mass and velocity are maximum—that is, before any of it has been condensed—in order that the surface of the tubes may be swept clean of both air and water films. This is probably the explanation of the high coefficients of heat transfer, exceeding 1,500 B.t.u. per square foot per hour per degree, observed by Orrok and other investigators, in the *front-line* tubes of a condenser.

In the light of the foregoing discussion it is easy to understand why a large condenser is less efficient than a small one of similar proportions. The inner tubes of a condenser bank are evidently less efficiently used than the outer. Furthermore, the ratio of outer tubes to the total number is generally lower in a large bank than in a small one, and the efficiency will therefore be lower.

During recent years, after a considerable period during which every effort seemed to be directed toward the improvement of air-removal methods and equipment, the trend of progress in condenser design has been toward an increase in surface efficiency: First, by increasing the proportion of "front-line" tubes, and secondly, by increasing the penetration of the steam into the condenser bank.

These two conditions are closely allied, and differentiation between them is not always easy. The improvement in the penetration has been secured generally either by reducing the resistance to the steam flow by providing wide steam paths between tubes at the surface of the bank, where the volume of the steam is large, so as to avoid choking off the flow at the first contact; or by means of deep steam lanes purporting to lead the steam into the heart of the bank. The first of these two methods is undoubtedly the more effective one. The increase in the proportion of "front-line" tubes has usually been effected either by exposing a larger part of the periphery of the bank to the steam flow, or by breaking up the tubes into a number of isolated clusters, each constituting a small condensing unit.

All the foregoing expedients aim to place as much as possible of the condensing surface in the "front line," with respect to the steam flow, and are more or less successful in attaining this object. Without doubt, none of

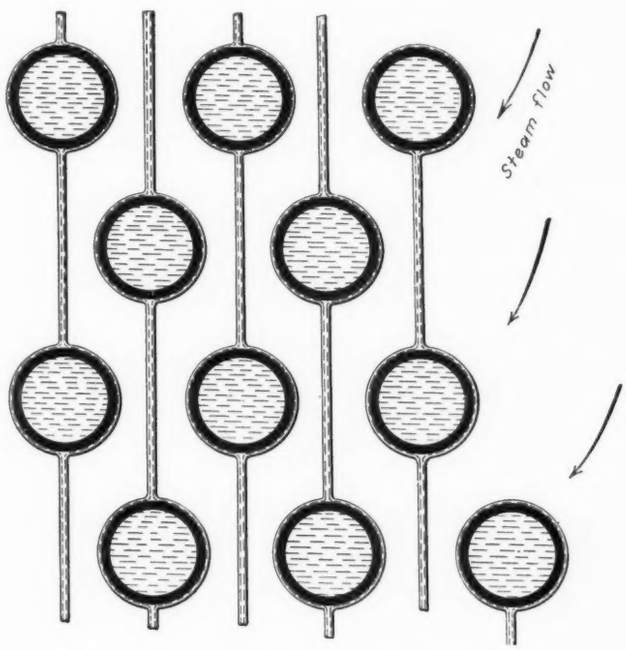

Fig. 1—Usual arrangement of condenser tubes

them offers any promise of improvement in the average efficiency of heat transfer to anywhere near the values attainable in tubes exposed to the direct impact of the steam.

Until 1921 little progress had been accomplished in France along the line of more efficient use of the condensing surface. At this time the French Navy undertook a series of tests covering a novel tube layout devised by a naval officer, A. Ginabat. Condensers built according to the new design were shortly after ordered for two destroyers. Ginabat's work was then taken up and extended to the industrial field by A. Délas, and a number of condensers of this type are now in service in central stations in France and Germany.

The principal characteristic of the Ginabat design is the high proportion of "front-line" tubes, which is still more marked in the latest Délas designs. The next most striking characteristic of this layout is intended to increase the efficiency of the condensing surface placed in series with the front-line tubes, by eliminating the evils of flooding. This is accomplished by arranging the tubes for tangential flow of the condensate. In most

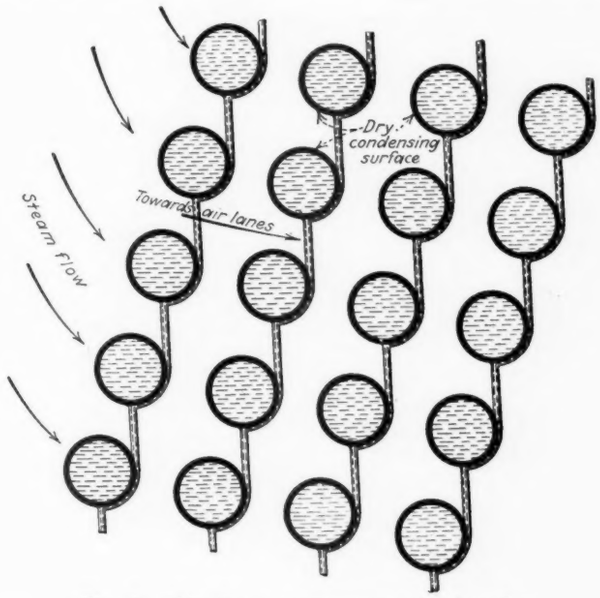

Fig. 2—Ginabat arrangement of tubes for tangential flow of condensate

condensers the tubes are centered on vertical and horizontal lines, as in Fig. 1, so that any tube receives the condensate from all tubes placed vertically above it. Ginabat placed the tubes as in Fig. 2, so that the vertical dropped through the center of one tube is tangent to the circumference of the tube below. In this way a drop falling from an upper tube strikes the next one tangentially, flows rapidly around one quarter of the circumference and drops to the next tube.[1]

There are two principal advantages secured by the Ginabat tube layout. The flow of the condensate may be directed through the condenser without the use of baffling, therefore without interfering with the steam flow. The condensate from the upper tubes wets only one-third of the surface of the lower ones, leaving the remaining two-thirds free of all moisture other than that resulting from its own condensation.

This is very important, for in these condensers the tubes are arranged so that the condensate flows along the leeward portion of the tube surface, with respect to the steam flow. The steam, therefore meets a surface as nearly dry as possible. Furthermore, cooling of the condensate is reduced, for the latter comes in contact with a relatively small proportion of the tube surface.

[1]The idea of disposing tubes for tangential flow is not new in itself, being covered by an old patent. It had not been applied to surface condensers before Ginabat.

Surface-condenser design, in France as elsewhere, is in a period of transition, and the fundamental conceptions upon which Ginabat based his original designs are changing so rapidly that an attempt to follow their evolution, to reconstruct a motion picture of their growth, will be instructive in determining their future possibilities. For this purpose four stages in their development will be briefly analyzed. Fig. 3 shows the tube layout of condenser No. 1 of the Gennevilliers central station and may be taken as roughly typical of European condenser practice prior to 1922; it has some points in common with American practice up to that time.

DATA ON GENNEVILLIERS CONDENSERS
UNIT NO. 1

Total surface—37,650 sq.ft.
Number of tubes—7,500.
Material—Brass.
Size of tubes—0.787 in. inside, and 0.866 in. outside.
Diameter of shell inside—12 ft. 6 in.
Length between tube sheets—22 ft. 3.5 in.
Volume between heads—2,736 cu.ft.
Surface per cubic foot of volume—13.76 sq.ft.
Circulation—Single-pass.
Condensing surface per kilowatt—0.941 sq.ft.

The following features of the tube bank are to be noted:

1. The massed arrangement of the tubes, filling the condenser shell almost completely, with the exception of the rather large steam space above the bank.

2. The then usual arrangement of the tubes, centered on vertical and horizontal lines, at the vertices of equilateral triangles.

3. The deep, winding and ramified shape of the steam lanes, which are expected to lead the steam deep into the heart of the condensing surface.

4. The small proportion of air-cooling or devaporizing surface.

The high efficiency of the front-line tubes above line *A-A*, Fig. 3, is self-evident. Below this line, however, it does not seem likely that the exhaust steam can retain much of its original kinetic energy. Now, if the tubes in the steam lanes, and particularly at the bottom of the latter, are to condense steam with any reasonable efficiency, it will not be sufficient for the steam to "percolate" through the lanes. It must move through them at relatively high velocity, probably not less than 50 to 75 ft. per sec. This can occur only if the steam is subjected to a relatively high pressure drop. In fact, the steam lanes should be considered as a kind of steam nozzle, the object of which is to deliver steam at the required velocity as far as possible into the tube bank. But, inasmuch as it must deliver steam also along its whole length, this nozzle combines every conceivable obstacle to the maintenance of rapid steam flow. Under these circumstances it is quite hopeless to expect that the tubes facing the lower part of the steam lanes could be made to exceed 10 to 15 per cent of the efficiency of the top tubes, particularly as they are subject to flooding. The steam lanes are probably continually choked up with slow-moving steam that has lost practically all power to sweep the tube surface clear of air and water films.

The inner tubes of the bank of this condenser undoubtedly have some effect in the condensation of the steam. Those located in the few first layers above line *A-A* may even operate at relatively high efficiency; for the high pressure drop through the bank may force the steam through the interval between tubes at sufficient velocity to maintain its power to sweep the surface of these tubes clean. But it is most unlikely that any of the inner tubes below line *A-A*, and particularly those at the bottom of the bank, can have any appreciable condensing capacity, flooded as they are with condensate from the upper tubes. Their rôle is probably limited to devaporization.

The small proportion of air-cooling surface in condenser No. 1 is surprising to those accustomed to American double-pass practice, and is a characteristic feature of all Délas designs.

Condensers No. 2, 3, 4, and 5, Gennevilliers Station, are idential and are equipped with identical auxiliaries. They contain the same amount of condensing surface as No. 1, and all their proportions are the same. The tube layout alone is different, being the original Ginabat design. Referring to Fig. 4, which gives a cross-section of the tube bank of these condensers, one is immediately struck by the "open" design. The steam lanes of the previous condenser have been replaced by wide and deep gashes in the bank, the object of which is to use the velocity head of the steam as it enters the condenser shell to carry it as far as possible into the heart of the condensing surface with a low velocity drop. For this purpose the width of these lanes decreases from top to bottom to allow for condensation and the resultant reduction in the volume of the steam flow.

An important innovation is the arrangement of the tubes for tangential flow of the condensate. Every layer of tubes presents toward the onflowing steam a surface free of all moisture other than that produced by the condensation on each tube. The condensate drops along the leeward face of the tubes. In this way the work required of the steam after it has passed through the first layer of tubes, to sweep the surface of the next layers clean of air and moisture, is reduced to a minimum, and it may be that the steam will retain sufficient velocity, at least for the first two or three layers, to accomplish this object.

Another feature of these condensers is the appearance of well-defined air lanes. The tubes are separated into ten groups draining their condensate alternately toward the left and right, as indicated by the arrows in Fig. 4. These groups are separated from each other by the steam lanes and by irregular and narrow air lanes *a*.

The short path provided for the steam between the steam and air lanes should also be noted. Barely twelve or thirteen layers of tubes separate the two lanes, which results in a very low pressure drop through the bank, claimed to be of the order of one-sixteenth inch of mercury.

On close analysis several features in this tube distribution will appear open to criticism:

1. The object of the layout—to present at all points a dry surface to the steam flow—is not attained in the lower half of the steam lanes.

It may be seen, by tracing the path of the condensate from each group of tubes, as indicated by the arrows, Fig. 4, that the condensate drains back into the steam lanes. The front-line tubes in the lower part of the latter are certainly completely flooded, and the only usefulness of this portion of the lanes is to lead the condensate through to the hotwell.

2. *In some parts of the tube bank the condensate comes in contact with a large number of tubes (40 or 50) before it escapes to the hotwell.*

It is debatable whether this condition is to be considered as a disadvantage or the reverse. The natural inference is that it will result in unnecessary cooling of the condensate. Yet this is not borne out by test results on these condensers; for the hotwell temperature is usually within less than 1 deg. F. of the steam temperature.

As in the preceding case, it is questionable whether this condition is a disadvantage or the reverse. For the first two or three layers of tubes the result is probably beneficial, in that the falling condensate undoubtedly condenses small quantities of steam, which tends to maintain the water temperatures close to those of the steam. However, as the steam-air mixture grows poorer in steam, its velocity drops to almost nothing; and the falling condensate certainly tends to entrain the air with

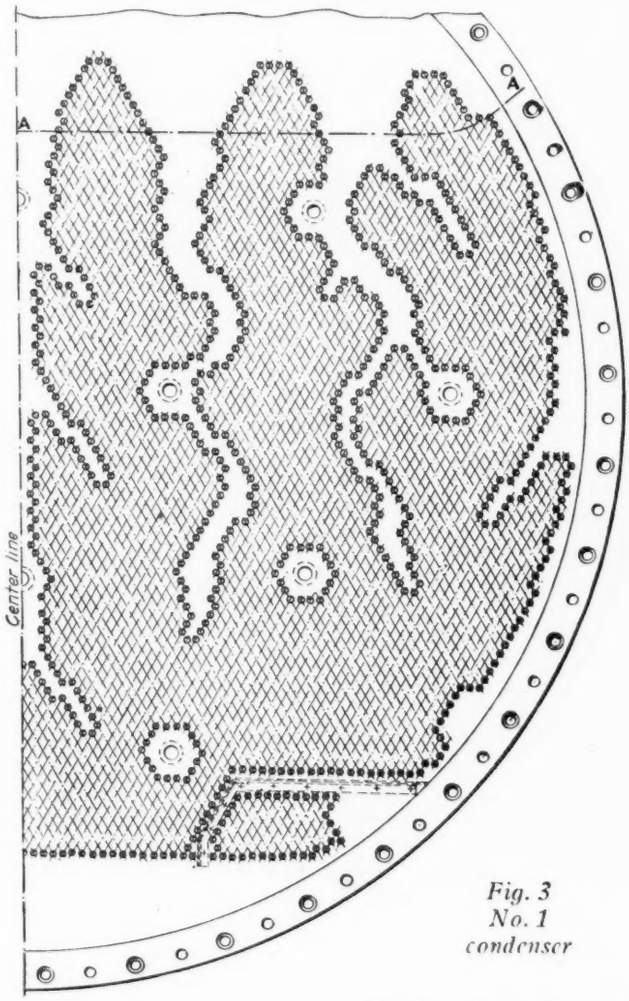

Fig. 3
No. 1
condenser

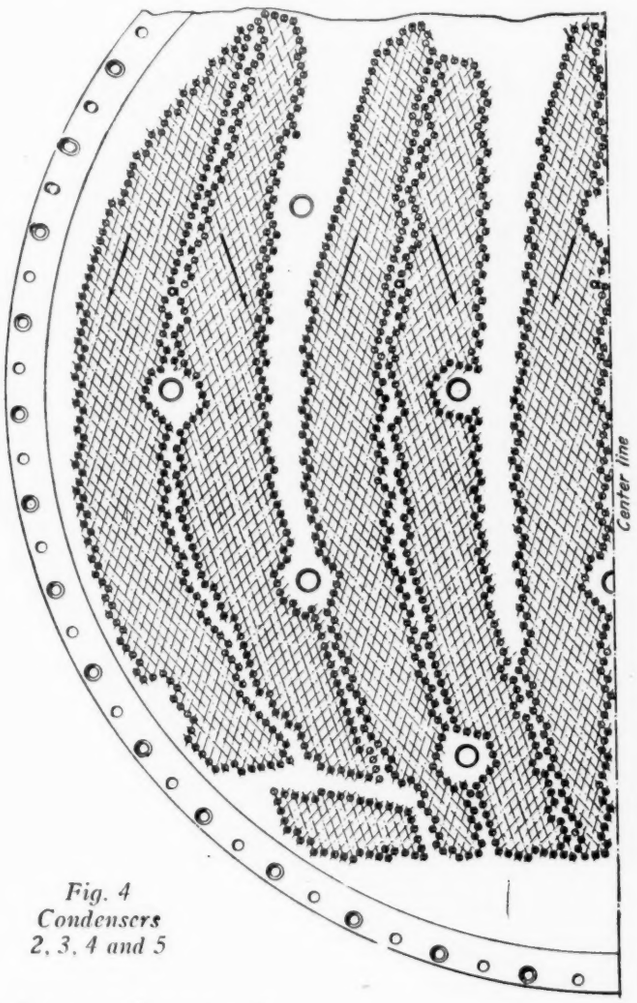

Fig. 4
Condensers
2, 3, 4 and 5

Tube sheet layouts for condensers in Gennevilliers Central Station

In reality the condensate is probably cooled materially during its passage through the tube bank, but is reheated in the steam lanes, where it streams through an atmosphere of fresh steam. This is, therefore, another form of the practice so widely used at the present time in American condensers, which has the double advantage of reheating the condensate, unavoidably cooled to a certain extent by contact with the tube surface, and of contributing in a small measure to the condensation of the steam by a jet-condenser effect.

3. *The steam and air flowing through the bank from the steam lanes to the air lanes must pass directly through successive streams of falling condensate.*

it through the tube bank around active condensing surfaces, thus retarding its escape to the air lanes. Furthermore, there may be an appreciable tendency for the condensate to reabsorb some of the air, its affinity for the latter being materially increased by cooling.

Of the three defects herein discussed, the first is probably the one having the most effect on the surface efficiency of the condenser; for the loss of the condensing effect of the front-line tubes in the lower part of the steam lanes must have a distinctly detrimental result on the performance. The changes made in the latest designs to correct these defects will be discussed in a second article to be published soon.

Modern BOILER *Problems*

By A. G. CHRISTIE

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WHEN low boiler furnaces were in vogue twenty years ago, the problem of boiler design consisted principally of the determination of the best disposition of convection surfaces to secure the most effective heat transfer at the low ratings then common. The advantages of larger furnace volumes to permit more complete combustion of fuel with less excess air, and consequently with higher furnace temperatures, later directed attention to the possibilities of radiant-heat transfer. As a result of these studies larger proportions of the boiler surface are exposed to the radiant heat of the flame.

The introduction of powdered coal led to the use of water-cooled side walls to withstand the higher furnace temperatures and the slagging effect of the ash. These water-cooled wall elements are connected into the boiler circulation system and receive large amounts of radiant heat from the fire, either directly or indirectly through protecting refractories. Increased size of furnaces permits the rapid combustion of large quantities of coal. As a result of these developments boilers must now be designed for both convection and radiant-heat transfer and for much higher ratings than in earlier days. Furthermore, the addition of water-cooled furnace walls has developed new problems of water-circulation that still tax the ability of the most competent boiler designers. The effect of scale, soot and refractories on conduction are quite marked where heat transfer rates are high and must therefore receive special consideration in the design of modern boilers.

> High furnace temperature is desirable to increase radiant-heat transfer, but does not increase convection heat transfer by nearly such a large amount.

How can boiler surface be most effectively disposed around the source of radiant heat? How much convection surface can be justified in a modern boiler? What are the limits of air preheating and where have economizers a proper place? What form will the energy generator of the future take?

The rate of radiant-heat transfer varies as the difference of the fourth powers of the absolute temperatures of furnace and tube surface. Hence, a relatively small increase in furnace temperature results in a comparatively large increase in radiant-heat transfer. High furnace temperatures are therefore desirable for rapid heat transfer by radiant energy. Heat transfer by convection, on the other hand, appears to vary directly with the difference in temperatures of the hot gases and the tube surfaces. Hence, equal increases in gas temperatures are not as effective in increasing the heat transfer rate by convection as by radiant heat. It would be natural to conclude, therefore, that the use of radiant-heat absorbing surface should be extended to its economic limit in modern boilers. There is a limit to the amount of this surface that may be installed on account of its cooling effect on the furnace with certain types of combustion equipment. Furthermore, there are only six sides to a furnace, and when these are completely water-cooled, the limit of radiant-heat absorption has been about reached.

> The trend in boiler furnace design appears to be toward the use of bare water-cooled walls except in special cases.

Many engineers believe that a completely water-cooled furnace is not desirable, as the walls may have too great a cooling effect due to rapid absorption of radiant heat, which may lead to incomplete combustion of the fuel. Areas of refractory surfaces have been introduced with certain forms of water-cooled walls to lessen these effects. Evidence is accumulating that indicates that water-cooled surfaces have little effect on the completeness of combustion or the efficiency of heat absorption when preheated air is used with underfeed stokers or with suitable turbulent powdered-coal burners. A general difficulty has been the inability, when operating at light loads, to maintain good air distribution in stokers and the necessary turbulence with powdered coal. Improvements in combustion equipment will overcome this difficulty. The trend in boiler furnace design appears to be toward the use of bare water-cooled furnace walls, although some refractory surfaces may be found desirable under certain conditions and with special fuels.

When radiant-heat absorbing surfaces are greatly extended through the use of water-cooled furnace walls, it would seem logical to reduce the convection surfaces of the boiler. This redistribution of heating surface may have little appreciable effect on boiler and furnace efficiency. With given furnace and flue-gas temperatures,

the efficiency can be considered substantially the same regardless of the form of heat-absorbing surface that may be placed between furnace and breeching, disregarding for the moment possible radiation or infiltration losses. This is borne out by the fact that the boiler, furnace and economizer efficiency of 92.3 per cent, secured on the boilers at Lakeshore Station, Cleveland, in 1924, with small radiant-heat and large convection and economizer surfaces, has not been exceeded to date by records of any of the newer boilers provided with extensive radiant absorbing surfaces.

Violent circulation is necessary to sweep away steam bubbles as rapidly as formed and keep the surface wet.

If the convection and economizer surfaces are cheaper than water walls, for equal performance, the latter are not justified provided furnace walls of some other construction can be cheaply maintained. On the other hand, if water-cooled walls are necessary around the furnace to cheapen wall maintenance on account of ash trouble, the extent of proper convection, economizer and air-preheater surfaces again becomes a question of costs, boiler pressures and load factors. Which is cheaper, to put added surfaces in the convection portion of the boiler or in the air preheater, for the same ultimate performance? Steaming economizers are favored in some cases for high-pressure boilers on account of the large sizes of air preheaters that would be needed and the excessive temperatures that result from their use. The steaming economizer appears to the writer to represent merely a transition stage in development. Additional high-pressure bleeder heaters and larger air preheaters involving the use of more highly preheated air, may supersede the steaming economizer in future central stations.

Little is known, and much knowledge is needed, on the safe and correct design of water wall circulating systems.

The modern steam generator will probably consist of a water-cooled furnace, the walls of which will absorb large quantities of radiant heat, together with certain convection surfaces placed above, below or at one side of the furnace, with or without economizer surface and with air preheaters. All this equipment will be capable of operation at higher ratings than in former practice.

A difficulty frequently encountered when boilers are operated at high ratings is due to the impingement of the flame on the first rows of boiler tubes and the deposit of small particles of liquid ash in the form of slag on these tubes. These slag masses grow in size and eventually join, closing off the gas passages between tubes. This is the commonly known trouble of "slagging" or "bird's-nesting" in the tubes. The writer has suggested in another article that this might be diminished, if not entirely overcome, by the use of large furnaces in which the flame at the highest ratings would have become quite transparent three or four feet before it reaches the tubes. If this upper portion of the furnace is completely surrounded by bare water-cooled walls, the radiant-heat absorbing effect of these surfaces would cool and solidify the liquid ash particles before they reach the tubes. The solid ash particles would not adhere to the tubes and would then pass up through the boiler as dust.

While this plan would seem to solve the difficulty, objections may be raised to it on the basis that an extra large furnace volume is required and, furthermore, that it is difficult to keep the flame from touching the tubes at high loads. It has been suggested that the slag-screen idea be applied to the first tubes of a boiler. To apply the screen idea in the case of boilers with horizontal water tubes, every fourth header could be extended down some distance below the others, and tubes carried across the furnace on about 28-in. centers. Every other tube on these headers could be omitted, giving a series of these tubes above one another that would serve as effective radiant-heat absorbers. The second intermediate headers between these could also be extended half the distance of every fourth header and with tubes so placed that a screen on 14-in. centers would be provided above the first screen in line with the second tube in the most extended headers. The gases would pass through two screens before reaching the regular tube bank which, as at present, could have the first two regular rows of tubes vertically above each other. Similar screen tube arrangements may be developed for Stirling and other types of boilers. This construction should be effective in reducing the slag nuisance, which has in many cases been the limiting factor controlling the rating that may be developed with a given boiler and furnace.

The effect of moisture in steam is so serious that much thought is now devoted to means whereby it may be eliminated.

Only pure water should be furnished to boilers that have large radiant-heat absorbing surfaces and that operate at high ratings. The rate of heat transfer is so great that the formation of any scale in the tubes leads to the overheating and burning out of tubes. If the impurities are soluble, the rate of concentration is such that foaming soon results or blowdown losses become excessive.

The regulation of boiler feed water has become difficult at high ratings. Feed-water demands may be large and sudden and require instant response from the regulator. This may necessitate the development of improved regulators.

A new phenomenon has developed with large modern boilers having entirely water-cooled furnaces that absorb

great quantities of radiant heat. When these boilers operate at high ratings, a large portion of the tube volume is occupied by the bubbles of steam that have been generated on the radiant-heat absorbing surfaces. If heavy load is suddenly removed from such a powdered-coal-fired boiler, the flame is virtually extinguished and there is no further source of radiant heat. Steam bubbles will cease to form. Water will then flow from the drum to fill the tube volume formerly occupied by the steam bubbles, at such a rapid rate that the water level may disappear entirely from the gage glass. In fact, in certain boilers all the water in the drum may be withdrawn under these conditions, and the circulation system be momentarily destroyed. As soon as load comes on and steam bubbles are again formed in the tubes, the normal water level will be restored.

During the outage the feed-water regulator will endeavor to restore the normal water level by admitting additional feed. If heavy load is again added, there will be an excess of water in the drum, which will probably cause water slugs or wet steam to be delivered to the superheater, disturbing the superheat. The design of a

Under comparable conditions the efficiency will be substantially the same whatever the disposition of surface between furnace and breeching.

feed-water regulator to meet these extraordinary conditions presents a new and difficult problem.

The specific volume of steam decreases with increasing steam pressure. Hence, for a given rate of evaporation there will be less fluctuation in the water level of the drum from sudden variations of load with high pressures than with low pressures. It is reported that little difficulty with water-level fluctuations has been experienced in the 1,200-lb. plants now in operation.

Feed water for boilers at high pressures and at high ratings must be as nearly oxygen-free as possible. Deaëration is therefore necessary either in the condenser or at some step in the feed-water heating. Oxygen leads to rapid corrosion in parts of the boiler and also in piping and turbines.

Water circulation has always received much attention in the design of boilers. Formerly, the rapid mixing of the cold feed water with the water already in the boiler was one of the objections of circulation, in order to prevent local stresses in the boiler material.

Modern boilers are fed with water heated more nearly to boiler temperature. Greater volumes of steam bubbles are formed on heating surfaces owing to higher rates of driving, and these must be removed as rapidly as formed to prevent overheating of the metal. Hence, the function of circulation in modern boilers is largely that of sweeping away steam bubbles as rapidly as they form on heating surfaces. It is obvious that there can be no difficulty in absorbing all the heat conveyed through metallic surfaces if these surfaces are completely covered and wetted with water at all times. Difficulties arise when steam bubbles are allowed to remain attached to these surfaces, retarding the absorption of heat, or when these accumulated steam bubbles do not find an easy and direct path to the steam drum and choke the tube and convert it into superheating rather than an evaporating surface. Violent circulation is necessary to sweep these bubbles

Proper construction should reduce the slag nuisance that has often limited the ratings attainable from boilers.

away as rapidly as formed and to keep the heating surfaces wet at all times.

Tubes have been lost in parts of water-cooled walls owing to improper circulation. Other causes may have been assigned to these tube failures, such as oxidation, dissociation, etc., but in the ultimate analysis the trouble will generally be found to have been due to circulation difficulties. Little is known of what takes place in a water-cooled tube of a furnace wall when this tube is exposed on one side only to radiant heat. The writer discussed this phase of the problem a year ago in a paper in *Power*, on "The Effect of Radiant Heat on Water-Cooled Furnace Walls." It is not known whether the water-steam mixture passes up the tube in slugs of water and steam, in a uniform mixture, or as alternate spirals of water and steam. Recent evidence indicates that such unusual conditions may occur as steam rising along the hot side of a tube, while water flows down the other side of the same tube with apparently little mixing. Such tubes eventually burn out.

The rate of heat transfer in the usual type of convection superheater, either inter-deck or above the tube bank, depends upon the temperature of the surrounding gases and their velocities. If excess air is high, furnace temperatures are low, radiant-heat absorption by the boiler decreases, and the gas temperatures at the superheater increase, resulting in increased superheat. Reduc-

For boilers with large radiant surface that operate at high ratings and loads, only pure, oxygen-free feed water should be furnished for feed.

tion of excess air has the opposite effect. Reduced superheat temperatures may be expected with convection superheaters and preheated air as compared with air at ordinary temperature, since the excess air ratio is generally lower with preheated air.

Radiant superheaters, being directly exposed to the temperature of the furnace, provide higher superheat with increased furnace temperatures such as result from the reduction of the excess air or from the use of preheated air. Lower furnace temperatures cause lower superheat in radiant superheaters. The radiant superheater is therefore affected in the opposite manner to the

convection superheater by variations in excess air ratios and changes in furnace temperatures.

There is some question regarding the endurance of radiant superheater tubes. A writer recently stated that with 300 lb. steam pressure and a steam temperature of 700 deg. F., the metal temperature of the front of the tubes ranged from 900 deg. to 1,000 deg. F., while the rear was about 200 deg. lower in temperature. This appeared to cause certain structural changes in the tube metal, so that its tensile strength was decreased. However, alloys that will serve satisfactorily are available for these metal parts.

The advantages of higher superheat than is now common practice are becoming recognized. Steam temperatures of 800 to 850 deg. F. have been used in Europe. When these superheats are used, care must be taken that no excessive fluctuations in superheat are permitted. Since the causes of high superheat are exactly opposite in nature in the case of convection and radiant superheaters, it would appear that the best insurance against excessive fluctuations in steam temperatures would lie in the use of a combination of these two forms of superheaters in every boiler. With the materials now available

With high steam temperature excessive fluctuations must be avoided. The best insurance lies in the use of both convection and raidant superheaters in combination in the same boiler.

for these two forms of superheaters, steam temperatures can be advanced to 800 deg. F. or possibly even beyond that point.

Central-station engineers were rather slow to recognize the possibilities of air preheaters and the advantages resulting from their use. Recent developments in preheated air have been forced by the extended adoption of bleeder heating of the feed water which made economizers unnecessary. Many forms of air preheaters are in use, and while these are functioning properly, there is room for much development in their design.

The air is preheated by its convection effect on the hot plate surfaces through which the heat is transferred from the flue gases. It will be apparent that the heater that will give the most effective transfer per unit of area at a given air velocity, will be the one with small air streams to provide turbulence, and with the most extended metallic heat-dissipating surface exposed to these air streams. The plate heater, as now built, could undoubtedly be improved on both the air and gas sides by the addition of partitions or strips to break the air and gas into small streams and to provide more extended heat-dissipating surfaces. The improvement in heat transfer should result in smaller, more compact plate preheaters than present designs.

Experience seems to indicate that air preheats of 300 to 400 deg. F. are about the limits for various types of stokers as now built. Increased maintenance and expansion difficulties fix this limit. Improved stoker designs may increase these limiting temperatures. There does not appear to be any limit to the degree of air preheat with pulverized coal on boilers with water-cooled furnaces. The probable limit will be that temperature of the air-preheater metal at which surface oxidation will become

With materials now available for superheaters steam temperatures can be advanced to 800 degrees F. or higher.

troublesome. Preheated air temperatures over 700 deg. F. are said to have been used in England.

The advantages of preheated air in providing higher boiler efficiency have been discussed elsewhere and are now quite generally recognized. One may expect the use of preheated air to increase even in relatively small plants.

The preceding paragraphs indicate that significant modifications have already been made in the form and functioning of vessels for the generation of steam. Further changes may be expected as knowledge of radiant heat, combustion and heat-transfer phenomena is increased. Little gain can be expected by increases in boiler and furnace efficiency as a result of these changes. Considering the hydrogen content of the coal, several boiler tests have already shown a plant economy within a few points in efficiency of the ideal. The gain must come in lower first costs and operating costs of the new units or in the provision of steam of higher pressure and temperature which can be used more effectively in the main turbine-generators. The thermodynamic cycles on which the latter operate necessitate the discharge of much of the heat in the steam at such low exhaust temperatures as to be of no further economic utility. The over-

Air preheats of 300 to 400 degrees F. are about the limit for stokers as now built. There seems to be no limit for pulverized coal with water-cooled furnaces short of the oxidation of the water-wall surface.

all efficiency from kilowatts to coal is lamentably low even in the best power stations.

Our scientists are learning new facts about wave energy and wave lengths. Possibly some day a transformer to change wave lengths may be developed. Then radiant heat—a wave phenomenon—may be transformed directly at the furnace into an electrical wave that can be usefully applied without any intermediate devices as steam boilers and turbines. Should such things transpire—and seemingly even more impossible inventions have been made—who can predict the form and construction of the energy generator of the future?

MANUFACTURED ICE INDUSTRY *Comes to Life*

By Van Rensselaer H. Greene
Consulting Engineer
New York City

THE owner of the typically modern ice manufacturing establishment is already in a position where he is securing a good product at reasonable cost. He accordingly looks on further refinements of his mechanical processes as less of a problem than the matter of organizing and operating his business as a whole in such manner as to yield greater profits and benefits for all concerned.

For all that, the technical end of the business is right now approaching the completion of a movement which, from the viewpoint of the recent past, is rather revolutionary. This is the substitution of electricity for steam as the customary motive power. Electricity came into the ice industry comparatively late. The chief reason for the delay was the previous necessity for using distilled water to secure a clear cake of ice. This necessity naturally brought the steam boiler into the ice plant as the source of power. In comparatively late years, however, methods have been perfected for making clear ice from raw water. These methods, in turn, have made possible the employment of electric power, which not only reduces power costs directly, but also results in another saving in labor costs, besides making a cleaner and a more compact plant.

There is, of course, no element of news in the application of electricity to ice making. What is significant at the moment is the continued steady transformation of the industry to the electric-raw-water method.

Apparently growing out of this application of electricity to ice manufacture, there has arisen a remarkable interest in ice on the part of the electric utility companies. It is already a common thing for the large power company to have several ice plants in its chain of properties. Few businesses could supplement each other more perfectly than power production and ice manufacture. The latter presents a peak load when other demands for power are at their lowest and a minimum load when other demands are highest. It thus brings a strong balancing force to bear on the load factor of the power plant. For this reason electric power companies are being attracted to ice manufacture as a field for their own activities.

Up to quite recently the business of manufacturing ice did not occupy a very high plane in the public estimation and the ice manufacturer himself made but indifferent efforts to elevate his business above the public conception. He was startled out of this attitude of sluggish indifference by the advent of the mechanical refrigerator. He awoke one morning to face the prospect of having almost his entire business wiped out by this device. To say that he was alarmed is to put the fact mildly.

When, however, the ice industry began to take stock of itself, it found not only that its fears of the mechanical refrigerator were greatly exaggerated, but that there lay in its own province enormous fields for future development which, in its previous blind complacency, it had completely overlooked.

It discovered that only 40 per cent of the nation uses ice at any time of the year, that for every ice box in this country we have two automobiles, that only 7 per cent of the people use ice all the year round. It saw that if it made any considerable headway in cultivating its own undeveloped markets, the inroads of the mechanical refrigerator, which can appeal, after all, to only a limited proportion of the population, would become utterly insignificant.

Strangely enough, the soundness of this point of view was most conclusively demonstrated by the sponsors of the mechanical refrigerator itself. For in a remarkably short time the realization was brought home to the ice industry that the exploitation of the mechanical refrigerator was *increasing the sale of ice!* The makers of household units were educating the people to the value of refrigeration, and the ice manufacturer was reaping a goodly share of the harvest.

But it is with regard to the front it presents to the consuming public that the ice industry is undergoing the most notable transformation of all. There is a growing realization that what the ice manufacturer offers for sale is not a piece of ice that is used up in a day, but a *refrigeration service* that continues through the years.

The various forces of publicity have been put to work not only to educate non-users and seasonal users to the value of ice all the year round, but to instruct ice consumers of all classes in proper methods of refrigeration and in the many and various ways that ice may be used to preserve the wholesomeness and improve the palatability of food.

A final trend in the ice industry, which is not a part of the general movement toward internal betterment but which is nevertheless of outstanding importance, is the growing tendency to regard ice manufacture as a public utility. One state, Oklahoma, has already made the business subject to regulation by a public service commission, and bills with a similar end in view have been introduced into the legislatures of other states. It is quite likely that the general recognition of ice manufacture as a public utility will take place throughout the country within the present generation.

All in all, the ice manufacturing industry is filled today with a spirit of enthusiasm and an ambition for bigger things which cannot fail to produce remarkable fruits, and though the future cannot be prophesied in detail, it is not a guess but a certainty that the whole industry is entering on the dawn of a brighter and more glorious day.

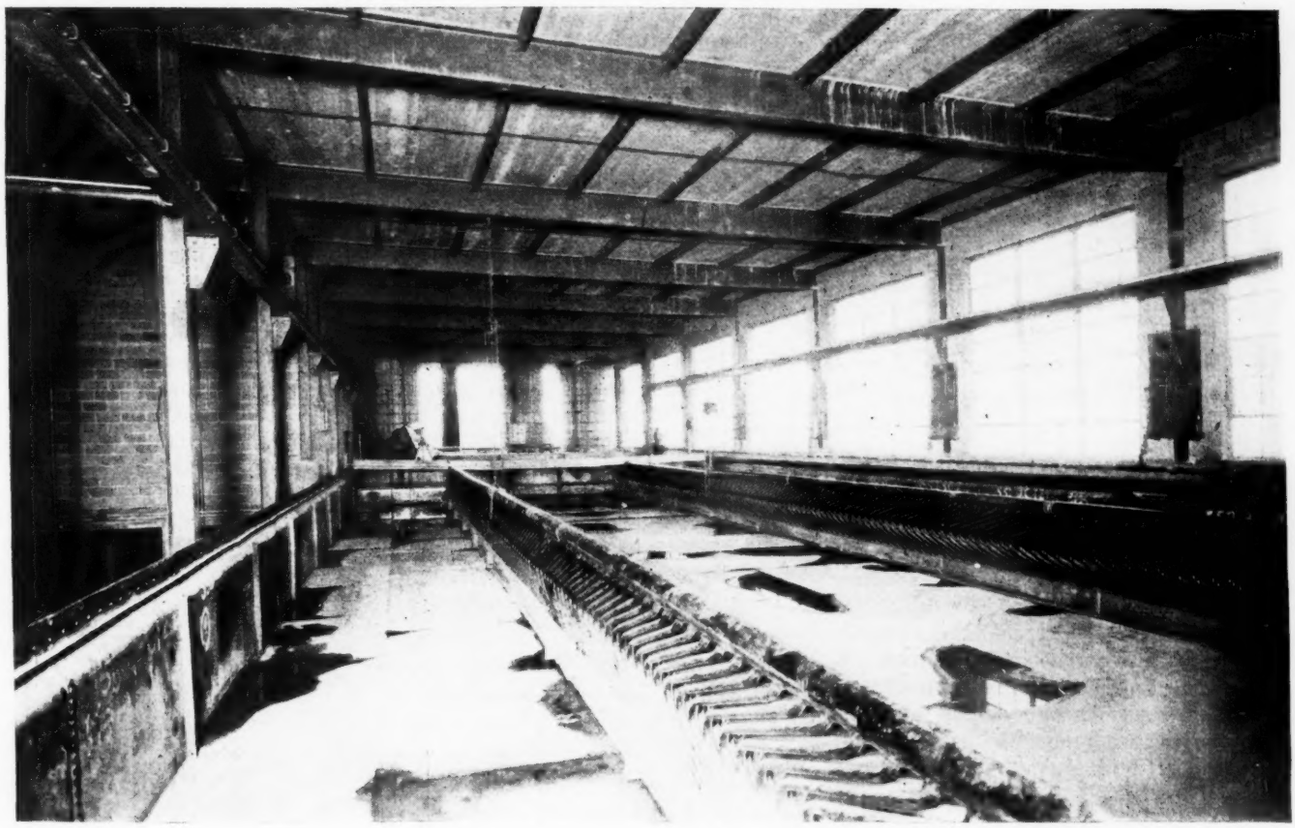

Fig. 1—The York coil system during construction

EVAPORATING SYSTEMS

Show Many Improvements

By F. P. MacNeil

AMONG the many great strides that have been made in recent years in the design of refrigerating equipment, the efforts to improve the ice-freezing tank have been productive of some ingenious designs.

The old-fashioned long coil possessed many disadvantages, which were never fully comprehended, the chief of these being the length and torturous nature of the path the vapor had to travel before it reached the compressor. This state of affairs gave rise to many difficulties such as excessive superheating of the suction vapor, intense "freeze-backs" to the compressor by which the suction pipe evaporated part of the liquid, with a resultant increase in power consumption and danger of wrecking the machine.

In the old days it was common to find a half a mile of pipe being fed by one expansion valve. It does not require a far stretch of the imagination to see that coils of this character must be operating with over 50 per cent of their length acting purely as a gas passage, if "freeze-backs" are to be avoided.

The flooded system was supposed to cure all this, but with its advent new difficulties arose. Small gas bubbles in the body of the liquid coalesced to form big ones that occupied the entire bore of the pipe, extending from three to ten inches in length. These became more numerous and closer together as the coil was traversed, and in trying to reach the outlet and discharge their contents, the slugs of liquid between them were carried out of the coil, into the suction pipe and into the compressor. To stop this action, the operator naturally closed in on the feed valve, thereby reducing the amount of liquid within the coil, often to the extent that the coil was only half full of liquid.

This caused the upper portion of the coil to be simply

a gas passage, and in this state it could do very little refrigeration of the brine. Consequently, the upper portion of the ice can would take twice as long to freeze as the lower portion, and when frozen, generally had a large bell-mouthed core. This was not the only difficulty, for when the ice was put into the thaw tank, the bottom

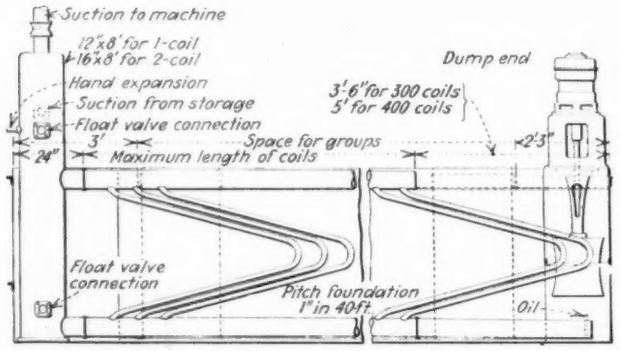

Fig. 2—Dimensions and design of the York coil

of the block being much colder than the top, the unequal contraction caused the block to crack.

Efforts of designers have been toward the development of evaporating coils or systems wherein the vapor can reach the suction line with the minimum of resistance, which will give a high rate of heat transfer by reason of increased brine or gas velocity.

After an extensive series of experiments in their research testing plant at York, Pa., the York Manufacturing Company developed the trunk coil shown in Figs. 1 and 2. This coil consists of two main headers, running lengthwise of the tank. Into these headers, whose diameters depend upon the plant capacity but averaging 6 in., are welded short lengths of $1\frac{1}{4}$-in. heavy pipe, bent to the form shown. This coil is made up in sections in the shop, and the sections are welded together on the job. The whole is incased in a steel-plate tunnel, or trunk, as it is called, so that a high brine velocity may be produced over this coil with the least expenditure of power.

In small tanks the coil runs through the center of the tank, the brine circulating as shown by the arrows. In larger tanks the coil is set off the center line, to one side, and in the large tanks two coils are installed.

There are no screwed or flanged joints to leak ammonia into the brine; everything is welded and subjected to a rigid test.

At one end of this coil can be seen a vertical suction trap or accumulator, forming an integral part of this coil, being welded to it. This device performs practically the same office as does the steam drum on a water-tube boiler. The liquid ammonia is fed into this drum by a float valve that keeps the liquid level constant under all conditions of service; therefore the coils can be kept full and working to their fullest capacity all the time. This does away with hand regulation and its attendant disadvantages of freeze-backs and half-empty coils. The float valve is so arranged that it can be adjusted without disturbing any part of the system.

The following are some abstracts from the log of the City Ice Company, Kansas City, Mo., which plant has this system: Condensing pressure, 147 lb. gage; temperature of water on condensers, 75 deg.; suction pressure, 25.5 lb.; brine temperature, 15.5 deg.; cans per ton of ice made, 12.6; compressor displacement, cubic inches per minute per ton of ice, 9,210; tons of ice per 24 hr., 96.6 (644 blocks averaging 310 lb. each); feet of $1\frac{1}{4}$-in. pipe per ton of ice made, 55.

Fig. 3 illustrates an ice tank of the brine cooler type, built by the Frick Company, of Waynesboro, Pa. The brine cooler has the advantage that there is an unrestricted release of ammonia gas from the liquid as fast as the vapor bubbles form. In addition it gives flooded operation and confines the ammonia to a single shell which occupies a relatively small space. It permits the use of high brine velocities over the evaporating surfaces, with a consequent high rate of heat transfer. The use of improved Halvorsen agitator propeller blades in connection with this tank has reduced the horsepower required for circulation to a marked extent. By allowing for free passage of the brine along the sides of the tank, dead pockets in the far corners of the tank are avoided. This tank may be supplied arranged for group lifts, either one-half or a whole row being harvested

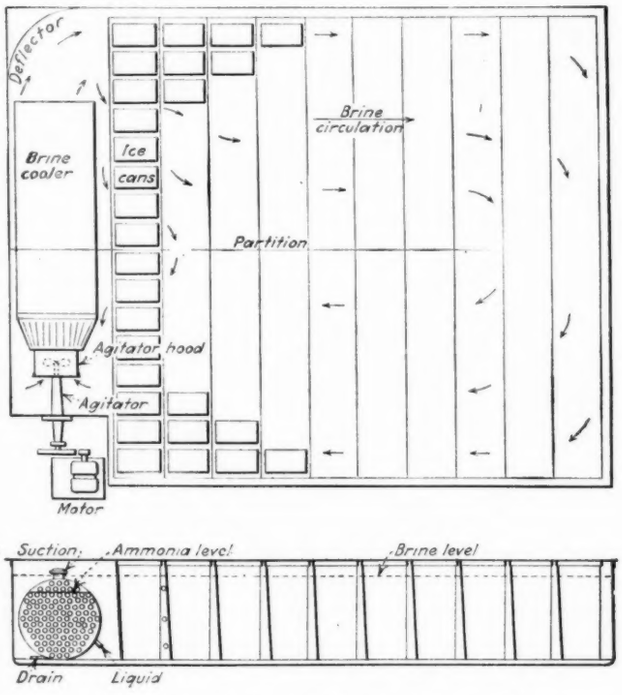

Fig. 3—The Frick shell-type brine cooler

at one time. The same tank may also be supplied for double or multiple-can lifts.

Large tanks are arranged with two or more brine coolers; these are frequently installed at the center of the tank with the brine circulating toward each end.

The Henry Vogt Machine Company, of Louisville, Ky., have concentrated their efforts on the plan of tank shown in Fig. 4. This represents a typical installation that they have recently made; two brine coolers are used, and the arrows show the paths of circulation. This tank is 29 ft. $1\frac{1}{2}$ in. wide, 147 ft. long, and contains 1,475 $11\frac{1}{4}$x$22\frac{1}{4}$x54-in. cans. The two coolers are 50 in. diameter, 14 ft. long, each containing 297 tubes.

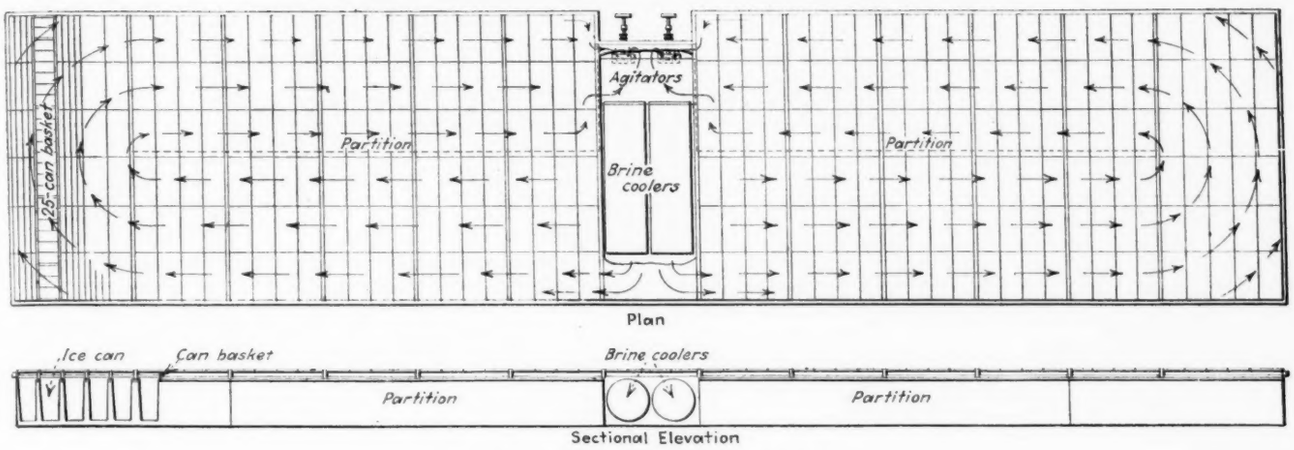

Fig. 4—The Vogt brine-cooling system

A single partition extends lengthwise of the tank, approximately at the center, as illustrated. The cans are arranged in racks for a full row pull of 25 cans. To remove the tendency to strata circulation that may sometimes prevail in cooler installations, where the warmer brine may circulate around the top of the tank and through the top tubes of a straight pass cooler, the Ball Ice Machine Company has installed a double-bottom tank, Fig. 5, in the Seaboard Terminal & Refrigerating Company's Jersey City plant. The bottom of the ordinary tank afflicted with this strata circulation is always much colder than the top, so in order to keep the ice from cracking, the brine temperature can never be carried very low, for the lower portion of the cake will freeze quickly, while the upper portion will take a long time to freeze. A cake frozen this way will be much colder at the bottom than at the top when put into the thaw tank, and will strain and crack.

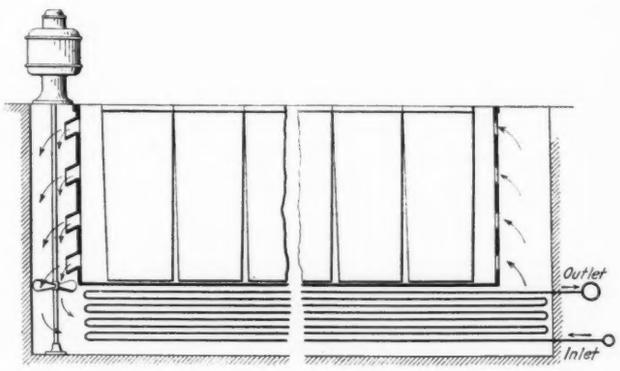

Fig. 5—Double-bottom tank in Seaboard Terminal & Refrigerating Company's plant

In the system used by the De La Vergne Machine Company, the coils in each tank are divided into four groups, each group having its own feed and connection to the suction header. The coils are arranged vertically between the wide sides of the cans and are ten pipes high and 68 ft. long. The great advantage of this coil is that each group can be purged of oil without disturbing the rest of the tank. Another great feature is that, when reducing capacity, the fact that the amount of pipe in the tank is divided into four parts permits the use of a variable amount of these parts, and thus gives flexibility to the operation. For instance, when it is desired to have the tanks produce a very small amount of ice, and where a small machine is available, such as a pump-out machine, three of the four groups may be cut out in each tank, leaving one group in operation. The system of agitator circulation may be so arranged that this one coil may be used as a bunker coil to refrigerate the whole tank. This method allows a very small machine to be used, whereas if all the groups were used, the amount of suction vapor coming from them would be too great for the small machine to handle. It will be obvious to many that there are other combinations that may be effected with this coil in reducing capacity.

In still another type of evaporating system, developed by J. R. Bernd, the coil is divided into two separate groups per coil, each group containing five 1¼-in. pipes connected to a liquid manifold and to the suction manifold in the upper group, as shown in Fig. 6. In this manner the gas travels only one-fifth as far per coil as it does in a ten-pipe hairpin coil.

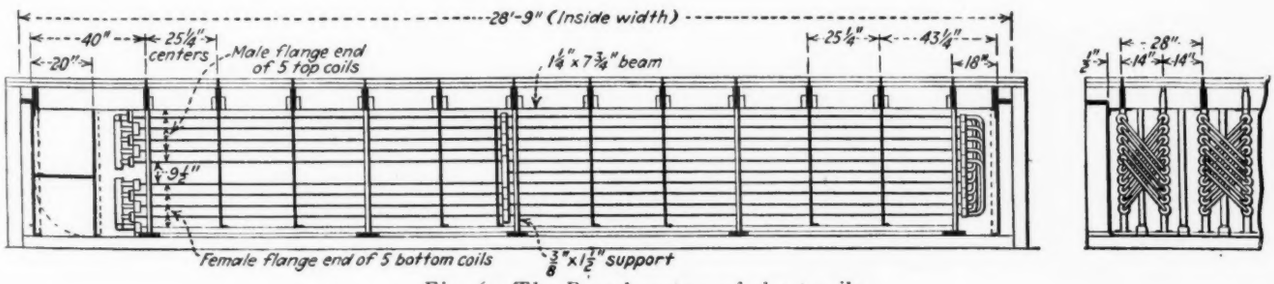

Fig. 6—The Bernd system of short coils

FUELS and COMBUSTION
In the Boiler Room

THERE has been much talk of the low-temperature carbonization of coal, with the production of coke and gas and by-products. Many installations in Europe and several in the United States are in operation on a larger or smaller scale, and as time goes on something widely applicable in practice will doubtless develop. The trend seems to be away from strictly low-temperature processes to what might be classed as medium-temperature carbonization, in which maximum yield of liquid by-products is sacrificed somewhat in order to increase the throughput and yield of high-grade carbonized fuel. At present, however, such things must be regarded as still in the experimental stage. On the other hand, it cannot be overlooked that contracts have been let for three or four really large plants using the K. S. G. process developed in Germany. One of these, now under construction, has contracted for the delivery of three million cubic feet of gas daily for ten years. This is certainly beyond the range of experiment.

Coal is coming to be regarded not so much as a raw fuel, but as an important raw material of industry that must be processed so as to derive from it all its diverse constituents, each for its highest possible use.

> WHILE it is true that there is nothing new under the sun, yet it is undeniable that there is a steady forward march in the century-old field of boiler furnace fuels and firing. Recent months have seen few startling innovations, but when one looks back a year or two he realizes that current practice is forging ahead.

Just what low-temperature carbonization may mean for the power plant is somewhat conjectural. Surplus gas may be burned under boilers, but gas is a fuel so ideal for other uses that perhaps it should be burned in the boiler room only in the absence of other demands. Coke will doubtless be available in large quantities, and if present indications are to be trusted, there will probably be a considerable percentage of fines. This suggests at once its use as pulverized fuel, but it must be remembered that most coke is distinctly abrasive. Mill wear and maintenance must be studied. If it proves infeasible to pulverize the coke, there is already available a reasonable body of experience in burning coke on suitably designed chain-grate stokers. Thus, while one cannot predict what method of coke disposal will finally prevail, it is certain that the coke will be useful for steam generation if not for other purposes.

Beyond this possibility in the low-temperature carbonizing field, together with the successful burning of newly discovered waste products, there is nothing new in the way of available fuels. There is no reason to expect anything else. It is, however, noteworthy that improvement in equipment and methods is extending the range of fuels that may be used with economic results. For instance, methods have recently been perfected for the burning of pulverized lignite in both stationary and locomotive boiler furnaces, with satisfactory results.

Equipment for burning fuels has been developed in a normal, steady evolution that seems to be going forward as fast as ever. On every hand one hears that pulverized coal has benefited the stoker. Whether this or some other influence be the dominant factor, it is true that marked improvements have been made in the design of stokers.

The underfeed stoker has undergone changes directed to eliminating its weaknesses of years gone by. The loss of unburned combustible with the ashpit refuse has been greatly reduced, and the ability of the stoker to handle coals of a wide range of characteristics has been considerably increased, particularly with respect to clinkering coals that formerly gave such serious trouble. Along with this the rate of combustion per retort has increased and the retorts have been made much longer.

The chain-grate stoker has not changed greatly in detail, but it has grown steadily larger. A recent report mentions a chain grate thirty feet wide—or was it twenty-five? At any rate, it will be a big one if it is built.

Pulverized coal has settled down to its rightful place in the industry. The view, so prevalent two or three years ago among those less familiar with the situation, that this new entry in the field presented all sorts of extravagant advantages over the stoker, is less conspicuous today. The element of faddism is evaporating, to the benefit of everybody, and the solid merits of both methods are coming to be seen with a clear eye by designers and operators.

Perhaps the outstanding question in connection with pulverized coal is its preparation. To secure adequate fineness at low cost is something of a problem, but progress is being made, and above all, the basic elements of the problem are beginning to be recognized.

Along with all this development on the fuel side there has necessarily been a thoroughgoing redesign of the boiler furnace. Refractories, once a most serious problem, are less important than formerly, at least in large furnaces, for the water-cooled wall is displacing the refractory. Even in small furnaces has this tendency been evident to some extent.

Ten years ago it was usual to remark that all the gains in the power plant were to be made in the boiler room. Today the boiler room has advanced to the point where further gains are probably not materially greater than those than can be obtained in the engine room. The power plant of today is a far better balanced engineering set-up than it used to be. And a right good job it is.

The STOKER *Does Its Job Better*

By J. W. Armour

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Riley Stoker Corporation, Worcester, Mass.

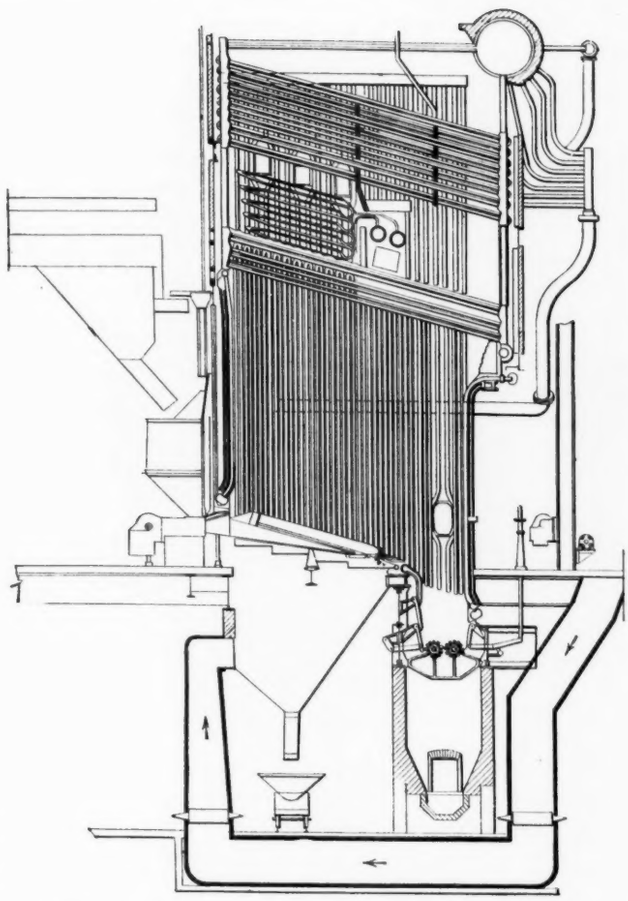


Fig. 1—Typical stoker furnace with water walls and preheated air

THE last two years have seen active and radical developments in stoker design. The rapid development of pulverized fuel, as applied to steam boilers, has no doubt furnished a large part of the incentive toward more active interest in the possibilities of higher efficiencies with stoker firing. Improvements in boiler and furnace construction, developed primarily for application with pulverized-fuel firing, have aroused interest in the possibilities of similar construction being used in connection with stoker firing.

To compete with pulverized fuel as applied to the modern steam plant, stokers must be capable of the high efficiencies, high capacities and accurate control that are generally obtainable with powdered fuel. They must, therefore, be applicable to furnaces surrounded with water walls, they must operate with air preheated to a high degree, and they must respond readily to rapid fluctuations in load and maintain high rates of combustion over extended periods. All this must be done with high efficiency.

These conditions have affected the design of stokers, particularly the large multiple-retort stokers. Within the next year there will be at least two central stations put into operation in which stokers will be used combined with many features in furnace construction usually found only in pulverized-fuel installations. At the Stamford Gas & Electric Company, Stamford, Conn., the furnace depth of 19 ft. 1 in. is one of the greatest ever installed. The forced-draft air will be preheated to 450 deg. F. All the furnace walls are water cooled, with little refractory exposed to the fire.

At the Kearny Station of the Public Service Corporation of New Jersey, water walls will surround all four sides of the furnace and even less refractory is to be used than in the Stamford furnace. Preheated air at 400 to 450 deg. F. will be used. Fig. 1 shows the layout of one of these jobs, and the other is closely similar to it.

Water walls in connection with stokers are not particularly new, but these are the first installations where all four walls have been so completely covered with water cooling. Front water walls carried down to the stoker involve a new problem in stoker design. There must be provided a coal and gas seal that will permit vertical expansion of the front-wall water tubes. This is accomplished by using a counterweighted seal as shown in Fig. 3. The seal, consisting of a casting, is hinged to the coal chute cover and held against the bottom header of the water wall by counterweights.

Another feature of this construction is the controlled admission of air at the front wall for burning the volatile matter released as fuel enters the furnace. One of the difficulties attending the admission of air at the front wall has been the lack of means to control it. Such control is advisable to provide for variation in the volatile content of the fuel. This has been done with sliding dampers built into the front wall so that air from the stoker plenum chamber is admitted over the chute cap under control of the operator. This damper is shown in Fig. 3.

A steel plate is provided between the stoker and side water walls. It is attached to the windbox, leaving the walls free to expand vertically, and provides a surface

against which the moving side tuyeres of the stoker rub. The pressure of coal in the side retorts forces the tuyeres against the steel plate so as to prevent leakage of air along the walls.

Accurate control of the air supply throughout the entire grate surface is important. This is being accomplished by zoning the forced draft throughout both the length and breadth of the stoker. Portions of the fuel bed that become thin or are naturally thin from their location, can be operated with reduced pressure, while the thick portions can be operated with higher air pressure. Proper proportioning of air to fuel is thereby accomplished. Air may be supplied in accordance to the variation in depth and density of the fuel bed. There is no necessity of attempting to average the air pressure and volume in accordance with the fuel bed conditions over a large area. This results in more uniform combustion over the entire grate surface and should aid in reaching higher rates of burning.

The type of stoker required for different grades of bituminous fuel should receive consideration. Low-volatile Eastern coals do not require as great a retort area in which to distill the volatile matter, and therefore the stoker should be provided with less ratio of underfeed to overfeed grate area. On Western coals containing high volatile matter the proportion of underfeed to overfeed should be increased so as to give a greater space in which to burn out the volatile matter. On some stokers the number of overfeed tuyeres can be varied without changing the tuyere supporting castings. It is possible to replace underfeed tuyeres with overfeed tuyeres, so that the stoker can be adapted to either low-volatile or high-volatile fuels, depending upon the location of the installation and the type of fuel it is proposed to burn.

With increased boiler sizes and the demand for higher steaming rates it has been necessary to increase the length of stokers in order to obtain the required grate area. This increase in length—in some cases double the practice common five years ago—means an increase in the amount of coal fed by each ram. This, in turn, results in higher speed of the driving mechanism. Larger rams have been adopted on some stokers, permitting the retention of the slow-speed driving mechanism with consequently few mechanical troubles.

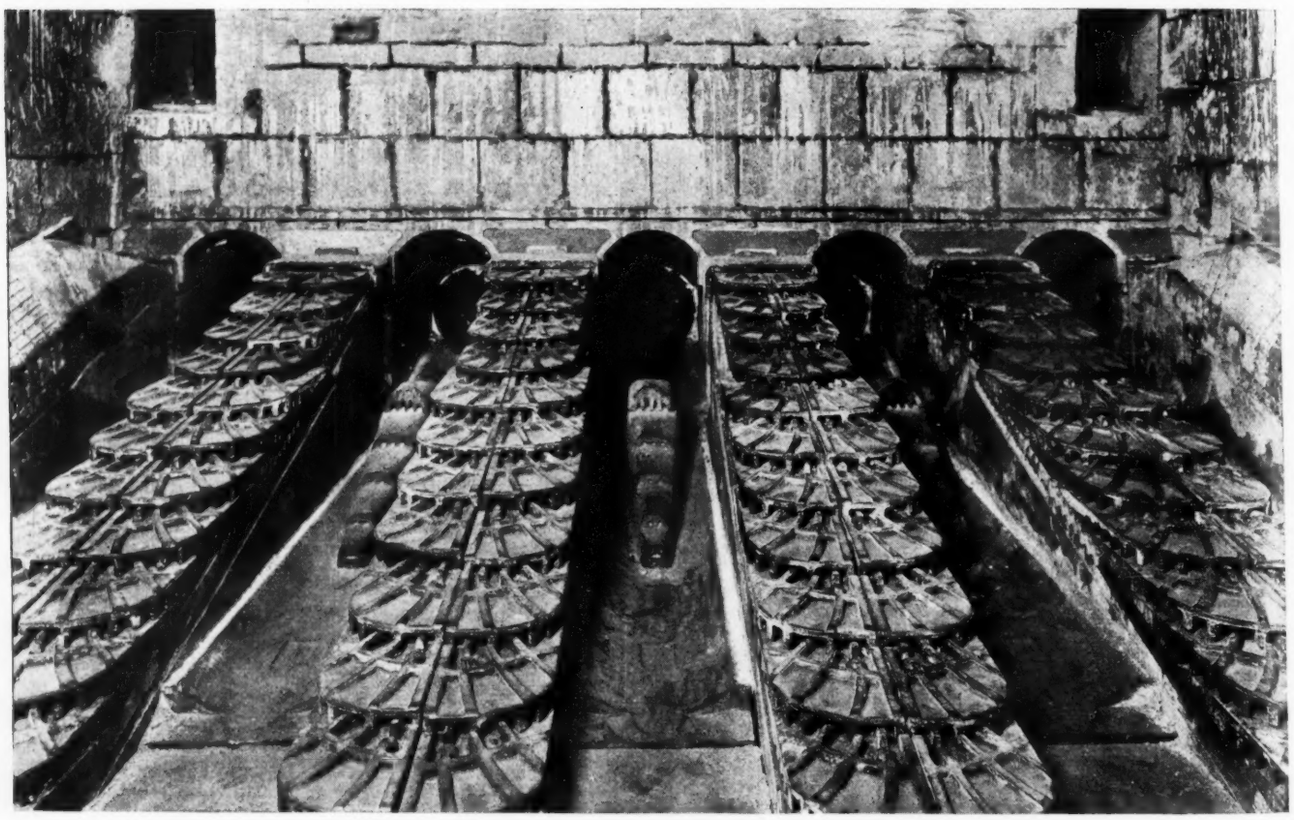


Fig. 2—Narrow tuyeres at the top leave room for a large coal-feeding ram

Increasing the size of the coal-feeding ram also means increasing the width of the retort. This is not always desirable, particularly when using preheated air. Fig. 2 illustrates how the large ram is used and yet the ratio of the tuyere area to retort area is kept in balance. It will be seen that the tuyeres increase in width a short way from the front of the stoker, the increase continuing through the length of the stoker to the overfeed section.

The greatest change in clinker-grinder design has been in the method of driving. Fig. 4 illustrates a clinker-grinder operating mechanism designed to give great flexibility with a wide range of control. Each grinder roll is driven by a ratchet wheel actuated by a pawl controlled by a cam so that it may be disengaged altogether or that one or more teeth may be engaged, according to speed of grinding desired. Since there are separate pawl control

cams for each grinder roll, either roll may be stopped altogether or operated at any speed up to maximum, independently of the other roll.

On smaller boilers using a single-retort underfeed stoker, the tendency has been to combine the driving mechanism to make a more compact unit. Usually, with such stokers the forced-draft fan is direct connected to the driving motor. A chain connection is made to the stoker gear box from an extension on the other side of the motor.

The two-speed gear box, found on most of the large

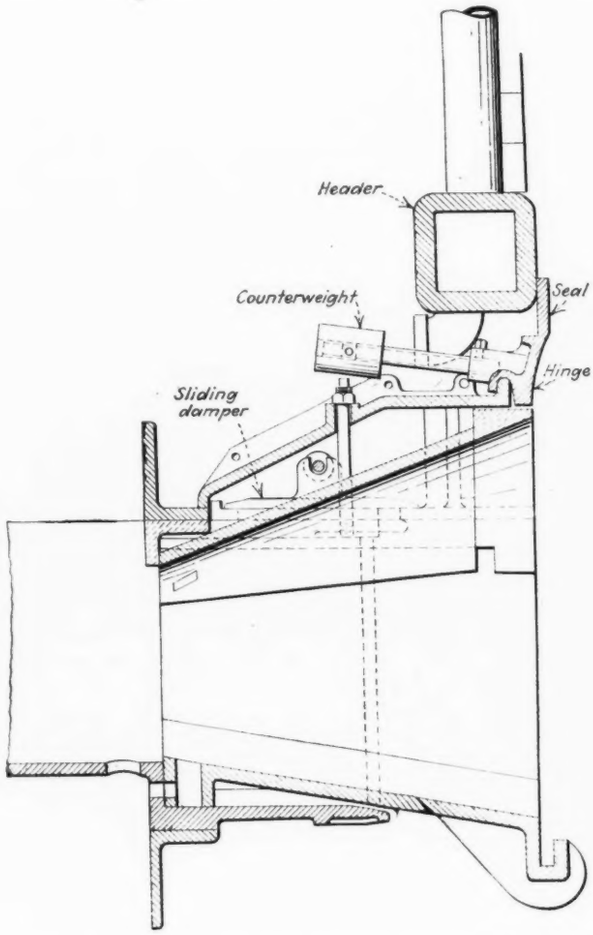


Fig. 3—An air seal that permits water-wall header movement, and over-fire air dampers

multiple-retort stokers, is appearing on the small single-retort stokers. Such an arrangement has a marked advantage where it is desired to feed a large amount of coal in a short time, such as upon banking or starting.

The two-speed gear device is an indication of the tendency toward the desirability of obtaining mechanically a still greater variable speed. One of the main objections to electrically driven stokers is the difficulty of obtaining proper speed control. This is particularly true when it is necessary to use alternating-current motors, for they are difficult to vary in speed, especially with the highly variable load imposed by a single ram. The advantage of using a constant-speed motor and varying the speed of the stoker mechanically is obvious. There have been

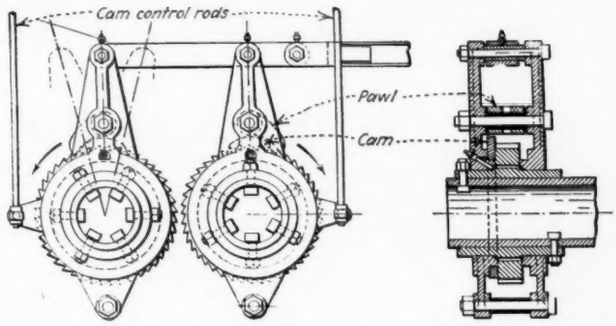


Fig. 4—Clinker grinder drive with pawl and cam control

drives of this type in operation for a number of years, but they have not been generally adopted.

The tendency of the small stoker seems to be toward mechanical drive, away from the steam-driven ram. This is probably due to the greater number of applications of underfeed stokers to small boilers, particularly for heating plants where low steam pressure precludes the use of a steam-driven stoker. The steam-driven ram still has the advantage of being capable of a greater range of speed in operation and ease of control. One of the greatest objections to the steam-driven ram has been the amount of steam used, and this has been overcome, to a great extent, by an improved type of control valve. This valve is of the poppet type and replaces the former disk valve. The operating and timing mechanism of the valve has also been improved by increasing the size of its bearings and strengthening the driving parts. An operating valve of this type is shown by Fig. 5.

More accurate control of forced draft is also reflected on the smaller underfeed stokers. Dampers are being provided in the air chamber to separate the underfeed from the overfeed section. High pressure can be maintained in the underfeed section where the fuel bed is thick, and low pressure in the overfeed section where the fuel bed is thin. A more active fire is obtained throughout the entire grate surface, and the torch-like action caused by air blowing out at the underfeed section, where the fuel bed is thin, is prevented. The result is lower grate and dump-plate maintenance and increased efficiency, due to reduction of excess air. The formation of slag, due to jet action of the flame upon the ash on the dump plates is also reduced.

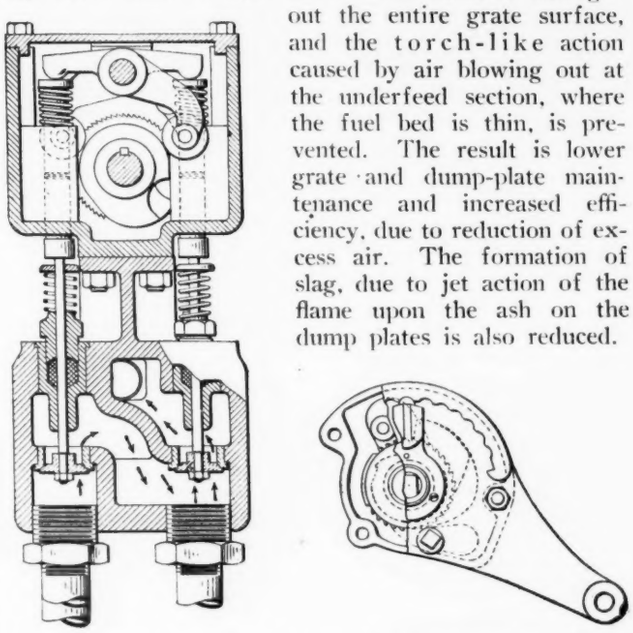


Fig. 5—One type of valve control for a steam ram stoker

How POWDERED COAL *Stands Today*

By Henry Kreisinger
Research Engineer, Combustion Engineering Corporation

A FEW years ago powdered coal was proved to be an economic fuel for making steam and since then has been making steady progress. Few new steam boiler installations are now planned without careful consideration of the possibilities of powdered coal. Many of these new installations are decided in favor of powdered-coal firing. Besides these new installations, many old units are changed over to powdered coal, particularly in industrial plants. The reasons for favoring powdered coal are principally higher operating efficiency and independence of variation in the kind of coal.

The percentage of ash in coal and its fusibility make less difference when the coal is burned in pulverized form than when it is burned on stokers.

It is generally admitted that with any given group of coals available on the market for a particular plant, the operating efficiency is higher with powdered coal than it is with any other methods of firing. The regulation of the fuel and air supply is simpler, permitting the operator to meet more easily any variation in the demand for steam and maintain efficient combustion. There are no interruptions in operation due to cleaning of fires. The furnace is always ready to meet any reasonable demand for steam. During the banking period the fire is simply turned out and there are no banking losses. Fires can be started on short notice and the boiler can be put on the line in the course of a few minutes.

The plant is independent of the kind of coal. Whether the coal is coking or free burning, high or low ash, the same coal pulverizing and burning equipment will handle it equally well. This cannot be said of stoker firing. A stoker designed for free burning coal will not satisfactorily handle coking coals. The percentage of ash in coal and its fusibility make less difference when the coal is burned in pulverized form than when burned on stokers.

The vertical method of firing was the first one to be developed, and most of the large plants burning pulverized coal are using this method. In most of the cases where this firing is used, only the primary air is supplied under pressure, the secondary air being drawn into the furnaces through the air ports in the front wall by the furnace draft. Owing to the fact that the secondary air is supplied with natural draft, the velocity of this air when it enters the furnace is low and it is not effective in producing intensive mixing. Whatever mixing is done must be accomplished with the energy delivered to the furnace by the primary air which is supplied under a pressure of five to twenty inches of water. Although in such installations the secondary air is supplied through many air ports distributed over the front wall, owing to its low velocity the mixing in such furnaces is limited and moderate rates of combustion are used. Generally, in these installations the furnaces are operated at the rate of heat liberation of 8,000 to about 16,000 B.t.u. per cubic foot of combustion space per hour. This rate of combustion is also limited by the fact that many of these furnaces are refractory lined. Higher rates of heat liberation would cause excessive erosion of the refractory furnace lining and high furnace maintenance. When operated under these conditions, these installations give very good results. In fact, some of the plants with hollow air-cooled walls and vertical firing and with secondary air supplied by natural draft show the best yearly operating efficiencies.

A few years ago powdered coal was proved to be an economic fuel for making steam, and since that time has been making steady progress. Few boiler installations are now planned without giving it careful consideration.

In later installations with this method of firing, where

air heaters are used the secondary air is supplied under pressure. The air ports in the front wall are reduced in size and also in number so as to make it possible to admit the secondary air at higher velocity and produce more intensive mixing of the secondary air and the mixture of primary air and coal. These installations also have either partly or completely water-cooled furnaces which, in combination with the more intensive mixing, make it possible to operate the furnaces at higher rates of heat liberation. Some of these plants exceed 25,000 B.t.u. per cubic foot of combustion space per hour. This method of firing is suited better for some coals than for others. High-volatile coals seem to give better results than low-volatile coals.

Horizontal firing is gaining in favor. Usually, its installation is simple and somewhat cheaper because no furnace arch is necessary. The burners are placed in the front wall, and the secondary air as well as the primary air is supplied under pressure. The burners are of greater capacity and there are fewer of them. Generally,

Some of the plants with hollow, air-cooled walls and vertical firing, and with secondary air supplied by natural draft, show the best yearly operating efficiencies. Horizontal firing is gaining favor, particularly for direct firing. Usually, its installation is simple and cheaper because no furnace arch is necessary.

all the secondary air is supplied through the burner. This supplying of both the primary and the secondary air under pressure produces intensive mixing, which in turn permits high rates of heat liberation. Whenever a high rate of heat liberation is to be used, water walls are employed to avoid excessive furnace maintenance.

On account of large capacity of the burners in horizontal firing, this method is adapted for the direct firing system because the coal from each mill is delivered to fewer burners and the pipe connection is thereby greatly simplified. In many installations one burner per mill makes a satisfactory arrangement.

Within the last few years several installations of pulverized coal were made, using the corner or tangential method of firing. In this method one or two burners are placed in each corner of a nearly square furnace. The streams of mixture of coal and air are projected toward the center, making tangents to a small circle in the center of the furnace. Where these streams meet intensive mixing is produced and combustion takes place rapidly. In some of the installations the burners are near the bottom of the furnace and the furnace gases move in the general upward direction. In other installations the burners are near the roof and the movement of the furnace gases is downward. In both locations of the burners the combustion is good, but that near the bottom of the furnace has certain advantages which will make it most favored in the future. One of the advantages is that the heavier particles of coal will tend to fall toward the bottom of the furnace against the flow of gases, and thus the falling of these particles will be greatly retarded and they will remain in suspension until almost completely burned or at least burned down to a size that enables them to remain in suspension. With top firing these

On account of large capacity of the burners in horizontal firing, this method is adapted for the direct firing system.

particles fall with the movement of the gases and their falling is accelerated with the result that the time during which they stay in suspension is much shorter. The corner, or tangential, firing is rapidly gaining in favor, and undoubtedly many installations with this method of firing will be put in in the near future.

With the corner, or tangential, firing the mixing in the furnace is so intensive that rates of heat liberation as high as 35,000 B.t.u. per cu.ft. of combustion space per hour are practicable. One condition incident to this method of firing is that there is considerable impingement of the flames against the walls of the furnace. If this method of firing were applied to furnaces with refractory walls, the abrasion of the refractories would be very rapid and the furnace maintenance high. It might be said, therefore, that this method of firing is made possible only by using a water-walled furnace.

The first applications of powdered coal to steam boilers were made with refractory furnaces. It was found that if the rate of combustion exceeded a certain limit the abrasion of the refractory walls by the molten slag was rapid and the furnaces required frequent repairs. To reduce the abrasion, air-cooled hollow walls were developed. In this type of construction the secondary

Within the last few years several installations of pulveried coal were made, using the corner or tangential method of firing with nearly square furnaces.

air used in combustion was first made to pass through horizontal channels, thereby cooling the walls. Many furnaces were built with this design, some of large size. The air cooling permitted a somewhat higher rate of combustion without serious abrasion of the walls. However, in most cases the rate of heat liberation had to be limited to less than 20,000 B.t.u. per cu.ft. of combustion space per hour. At higher rates the abrasion became rapid, necessitating frequent repairs.

The water-cooled wall furnace was developed to permit high rates of combustion. There are many designs on the

market, having for their main object the protection of the furnace wall against abrasion, low furnace maintenance and small percentage of outages due to furnace repairs. An additional advantage of considerable value with coal having highly fusible ash is that the gases and the ash which the gases carry are cooled to some extent before they strike the boiler heating surfaces. This cooling reduces the tendency of the ash particles to stick to the boiler tubes and clog the gas passages. It is therefore of considerable advantage to have the furnace of such design that the gases are cooled sufficiently to solidify the ash particles before they strike the boiler tubes.

Much has been said and written about the possibility of very high rates of combustion. Some engineers place the possible rate of heat liberation at 60,000 B.t.u. per cubic foot of combustion space per hour. Others go up to 100,000 B.t.u. and a few of them place it as high as 1,000,000 B.t.u. per cubic foot of combustion space per hour. The question is whether they mean the average rate of heat liberation for the entire furnace or for only certain portions of the furnace in which combustion is most intensive. If we take it to mean an average rate of combustion, such figures appear too high for any ordinary boiler installation. There may be some special cases where the rate of heat liberation of 50,000 B.t.u. per cubic foot of combustion space per hour might be found practicable. However, in such cases the coal would have to be carefully selected and finely pulverized, and the losses from incomplete combustion would have to be of minor importance.

An average rate of heat liberation of 100,000 B.t.u. with powdered coal appears too far in the future. We

There may be some special cases where the rate of heat liberation of 50,000 B.t.u. per cubic foot of combustion space per hour might be found practical. However, in such cases the coal would have to be carefully selected and more finely pulverized than usual, and the losses from incomplete combustion would have to be of minor importance.

may be able to burn oil or gas at such high rates, but these fuels do not have any ash to give trouble from slagging.

If the high rates of heat liberation refer only to that part of the furnace with the most intense combustion, there is considerable truth in the claims. Surely, the rate of combustion near the burner is much higher on account of greater oxygen and fuel concentration than it is in the combustion space just before the gases enter among the boiler tubes. Near the burner the oxygen concentration is about 20 per cent, and nearly 100 per cent of the fuel is available for combustion. At the end of the combustion space the oxygen is reduced to 2 or 3 per cent and the combustible still available for combustion is reduced to about 2 per cent of the original amount supplied by the burner.

If the rate of combustion at the two places under consideration is proportional to the product of only the first powers of the concentrations of oxygen and fuel avail-

An average rate of heat liberation of 100,000 B.t.u. with powdered coal appears too far in the future. We may be able to burn oil or gas at such high rates, but these fuels do not have any ash to give trouble from slagging.

able for combustion, near the burner the rate will be proportional to 20 times 100, which is 2,000, and near the end of the combustion space it will be, say, 3 times 2, which is 6. In other words, near the burner the rate of combustion is over 300 times as rapid as it is at the end of the combustion space. These figures of relative rates of combustion are obtained by assuming that the rate of combustion is proportional to the product of the first powers of the concentrations of oxygen and combustible. If we were to consult a competent physical chemist, he would tell us that the rate of combustion very likely is proportional to some higher power of the concentrations of the two substances going into combination. It is therefore entirely possible that the rate of heat liberation near the burner may be at least 100,000 and very likely considerably higher.

The average heat liberation for the entire furnace that is practicable with the present-day design of furnace and burner equipment varies with the furnace design, the method of firing and the fusibility of the ash. For solid walls and normal ash fusion the rate of heat liberation is 10,000 to 12,000 B.t.u.; with coals having high ash-fusion temperature this rate may go up to 15,000 B.t.u. With air-cooled wall construction and normal ash fusion the rate of heat liberation may be 15,000 B.t.u.; with high ash-fusion temperature the rate may be 17,000 or 18,000 B.t.u. In water-cooled wall furnaces with normal ash fusion the rate may be 20,000 to 25,000 B.t.u. and with high ash-fusion temperature, 30,000 to 35,000 B.t.u.

The rate of heat liberation of 35,000 applies to furnaces with the corner or tangential firing. With other methods of firing losses due to incomplete combustion would be too high for ordinary plants. By normal ash fusion is meant ash melting between 2,100 and 2,400 deg. F. High ash-fusion temperature is above 2,400 deg. F.

These rates of heat liberation may appear conservative, nevertheless they show the best present-day practice. A few years ago, after the first thorough investigation of the value of powdered coal as fuel for making steam, it was stated that good results could be obtained when burning coal at the rate of 0.6 to 2 lb. of coal per cubic foot of combustion space. This statement was made in connection with burning coal having a heat value of

about 12,500 B.t.u. This figure would make the heat liberation 7,500 to 25,000 B.t.u. per cubic foot of combustion space. A comparison of this early statement with the present-day practice shows the progress made during the last six or seven years.

In most cases the ash deposited at the bottom of the furnace is removed in granular form. Such removal is simple and can be handled as with stoker ash. Standard designs of ash-handling apparatus can be used.

In most cases some means is provided to keep the ash settled at the bottom of the furnace from fusing either by means of a water screen consisting of a row of tubes placed over the bottom of the furnace, or by water-cooled furnace bottoms.

Recently, a few installations have been made in which the ash collected at the bottom of the furnace is removed in liquid form. The molten ash is run out intermittently and dropped into a spray of water. It is chilled quickly and thereby disintegrated into small pieces which are floated into a settling basin. In order to run the ash out of the furnace in liquid form, high temperatures near the bottom of the furnace are required. The furnace

The slagging furnace would have a particular advantage for burning coal with very fusible ash. Such coals are difficult to burn in the ordinary furnace without causing the ash to stick at the bottom of the furnace and on the side walls.

bottoms are lined with firebrick protected with a layer of dolomite sand.

At the high temperature the liquid ash undoubtedly erodes the refractories, but no definite data are available to show how serious this erosion is.

The high temperatures maintained in the furnace tend to increase the slagging of the boiler tubes. An effective means must be provided for the removal of this slag.

The furnaces so far put in service are in operation only part of the time each day. When the fires are shut off, the slag on the boiler tubes cools and most of it falls off. If such units were in continuous operation, this cooling of the slag would not occur and there might be greater difficulties from slag on the boiler tubes.

The slagging furnace would have a particular advantage for burning coal with very fusible ash. Such coals are difficult to burn in the ordinary furnace without causing the ash to stick at the bottom of the furnace and on the side walls. With the slagging furnace the ash could be run out in liquid form without the necessity of very high furnace temperature.

Within the last year powdered coal has been applied to Scotch Marine boilers apparently with considerable success. High combustion rates were obtained, but it was necessary to pulverize the coal very fine so that 80 per cent or more passed through the 200-mesh screen. When attempts were made to burn coarser coal, the losses from incomplete combustion were large and there were some difficulties with slag. This experience would indicate that if the coal is to be burned at a very high rate, it must be pulverized very finely. Fine pulverization requires a large mill. The deficiency in the size of the furnace must be made up by an oversized mill. The coal burned under stationary steam boilers is pulverized

Within the last year powdered coal has been applied to Scotch Marine boilers, apparently with considerable success.

so that only about 65 per cent of it passes through the 200-mesh screen, and in some cases the coal is even coarser. This comparatively coarse coal can be burned because the furnaces are large. It would seem that for efficient burning of pulverized coal we must have either a large furnace or, if the furnace is small, a large mill to produce fine coal.

When burning pulverized coal, about 25 per cent of the ash is deposited at the bottom of the furnace and the remaining 75 per cent is carried out with the stack gases. In some cases the ash carried out of the stack may be a nuisance and therefore efforts have been made to devise means of removing this ash from the gases before they are discharged into the atmosphere. The electrostatic precipitator has been applied in two large plants apparently with good results. It catches from 80 to 95 per cent of the dust in the stack gases. The efficiency of the precipitation depends on the velocity of the gases passing through the precipitator; 6 to 10 ft. per sec. seems to give very satisfactory results. It appears that the precipitator catches most of the finer particles, allowing a greater proportion of the coarse particles to go through. As it is the very fine dust that gives the stack gases their color and cloudy appearance, this feature of electrostatic precipitation is an advantage. Most of the other methods of catching the dust catch the coarser par-

It would seem that for efficient burning of pulverized coal we must have either a large furnace or, if the furnace is small, a large mill to produce fine coal.

ticles and leave the fine particles to flow with the gases out into the atmosphere. Thus even though such dust catchers catch a large percentage of dust by weight, they leave enough of the fine dust particles in the gases to give them a color and cloudy appearance. In one plant experiments have been made with an air washer in which the dust was washed out by fine water spray and baffle plates. It has been reported that most of the dust was washed out of the gases, but the parts of the air washer were rapidly corroded and the apparatus lasted only a comparatively short time. If such a gas washer is to be successful, it must be made of non-corrosive metal.

ELECTRICAL POWER EQUIPMENT

Shows Many New Trends

ALTHOUGH, during the last year, there have been no developments in electrical power equipment that might be considered outstanding, there are many trends that are having a marked effect on the design. One of these is the use of electric welding in fabricating machine parts, from plates and shapes, that were originally cast. This has resulted in a reduction in weight of about 33 per cent. Electric welding is being applied not only to large units but also to small machines.

Both steam-turbine and waterwheel generators of the larger sizes are being built with welded fabricated frames. The reduction in weight allows the largest turbine-generators to be assembled in the shop and shipped as a unit with the core and windings in place. Stators for machines rated at 100,000 kva. have been shipped in this way. If cast frames were used, it would be necessary to ship the stators in parts and make the assembly at the place of installation.

GREATER use of welding in the construction of machine frames, use of hydrogen as a cooling medium for generators, closed systems of ventilation for waterwheel generators, quick response excitation system for generators and synchronous condensers, greater use of tap-changing equipment on transformers, and synchronous motors for general-purpose applications are some of the important developments in the electrical field.

As the size of turbine generators increased, the problem of properly ventilating them became more difficult. Experimental work done on the problem during recent years has removed the ventilation limitations on the size of single units. Closed systems of ventilation with air have become practically standard equipment. These systems are also being applied to hydro-electric generators.

Hydrogen as a cooling medium is being experimented with on machines up to 12,500-kva. capacity. Some of the largest machines have been designed so that this system of cooling can be applied if it becomes desirable to do so. One of the chief advantages of hydrogen cooling is that about 25 per cent greater capacity can be obtained from a given machine than when cooled with air.

Voltages at which generators operate, which remained at a maximum of about 13,000 for many years, are being increased. The 100,000-kva. single generator units installed by the Southern California Edison Company will operate a voltage of 16,500, and the 208,000-kva. triple unit for the State Line Generating Company, near Chicago, will operate at 22,000 volts. Sample coils for the latter machine have been tested repeatedly up to 75,000 volts with no indication of distress. The use of higher voltage simplifies transmitting the current of large machines and reduces the duty on the oil switches.

There is a tendency toward the use of high speed for turbine generating units. Two units rated at 94,000 kva. have been built to operate at 1,800 r.p.m. Owing to the use of structural-steel design, these machines were shipped completely built and wound.

The advantages of quick-response excitation on alternators and synchronous condensers, as a means of keeping them in synchronism during system disturbances, have been given considerable attention. Excitation systems for synchronous condensers have been designed for a maximum value of 1,000 volts, which can be built up at the rate of 6,000 to 7,000 volts per second.

Large transformers are fast losing their traditional appearance, by the addition of radiators for self-cooling and of air-blast adjunct for these radiators, and various forms of tap-changing switching devices. The switching devices are designed for changing the voltage of the transformers while under load. This system has been developed so that it can be made completely automatic. Such voltage adjustments have been made necessary by the large interconnected power systems. In some cases induction voltage regulators are combined with transformer taps. One installation of this kind gives a smooth voltage range over an adjustment of 43 per cent. This arrangement has the advantage that the size of the induction regulators can be greatly reduced compared to that necessary when the regulator must care for the entire range of voltage.

The attention given to power-factor correction during recent years has had a marked effect on the development of synchronous motors. This class of equipment, which a few years ago was limited to a few applications, has now come into use for a great variety of purposes. Not only the starting torque but also the pull-in torque has been increased to where the motor is comparable with the induction type. Illustrative of this is a 900-hp. 80 per cent power-factor motor to operate at 180 r.p.m. on 2,200 volts and be started on full voltage. This machine will develop 200 per cent starting torque, 105 per cent pull-in. torque and 225 per cent pull-out torque. At starting the inrush kva. is 275 per cent full load.

Other motor developments include totally inclosed fan-cooled types that are interchangeable with the conventional types, induction motors designed for across-the-line starting and refinements in direct-current-motor design.

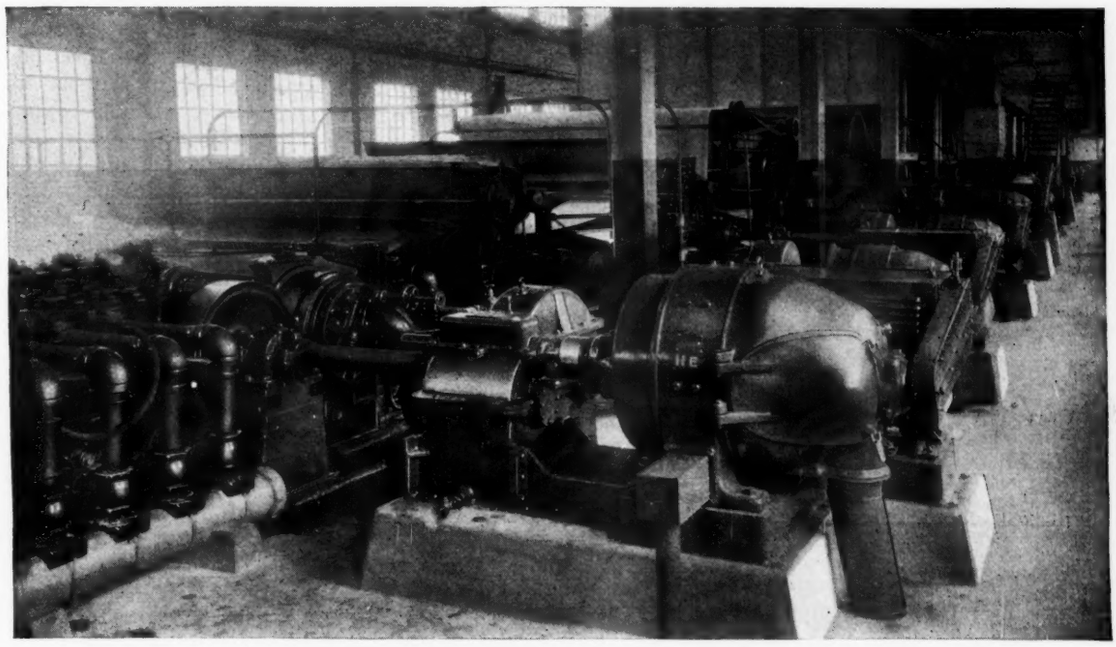


Fig. 1—Each direct-current motor drives a section of the paper machine through herringbone gears, while its speed regulator is chain-driven from the outboard end

MOTOR and CONTROLLER

Applications Improved

By R. C. Muir

Assistant Engineer, Industrial Engineering Department, General Electric Company, Schenectady, N. Y.

ELECTRIFICATION of industry is rapidly reaching a point where the user is demanding machines designed for electric motor drive and motors and control designed to suit the machine or specific application under consideration. During the first stage of this development only a part of the inherent advantages of electric drive was realized, but gradually the trade came to the realization that electric drive permitted of the design of machines that could do better and faster work.

When the electrification of industry began, motors were developed having electrical characteristics suitable for driving the machines as they were; that is, machines designed for other types of drive, usually by belts from lineshafts. The later stage has been along the lines of the development of machines primarily designed for electric drive, refinement in electrical characteristics of motors, improved mechanical construction of motors to meet the existing physical conditions and the development of control, so that now the full advantages of electric drive are being realized.

The results, from the users' point of view, are greater production and better products at lower costs; from the electrical manufacturers' point of view, an ever-increasing multiplicity of lines of motors and control. The end is not yet, as each year brings forth new motors and control developed for particular service conditions.

Improvements in motor applications are usually brought about by a demand for one or more of the following advantages: Increased reliability, increased production, less space requirement, better shop arrangement, greater safety, better appearance, lower first cost, improved power factor, lower unit operating expense or lower maintenance.

Usually, an improved application involves the complete machine with its motor, control and the connecting link between motor and machine; but if all these points were included, it would not be feasible, in one short article, to discuss even a small percentage of the recent developments. However, a few of the recent developments in motors which have a bearing on improved

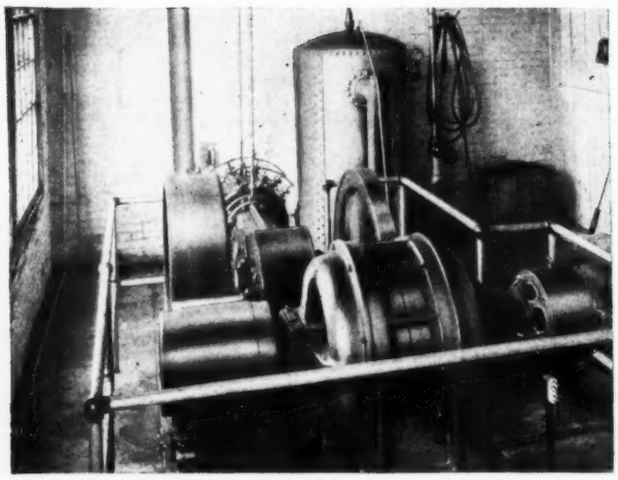


Fig. 2—Synchronous motor belt connected to air compressor

applications will be given consideration in the following:

The outstanding recent development pertaining to electrical characteristics is the so-called "full-voltage-start" motor with its starter, and the outstanding mechanical development is the so-called totally inclosed, fan-cooled motor. Incidentally, it might be said that there have been a number of other developments, such as improved insulation for more severe operating conditions, improved sleeve bearings for the exclusion of dust and dirt and the prevention of oil leaking. Improvements have also been made in the mounting of ball bearings, particularly in small induction motors up to fifteen horsepower, which permit the disassembly of the motor without disturbing the bearing. All these developments tend toward greater reliability in difficult applications.

Full-Voltage-Start Motors

The development of the so-called "full-voltage-start" induction motor was probably brought about by the demand for simple automatic equipment to drive refrigerating machines, small compressors, conveyors and other machines or devices requiring high starting torque with reasonable starting current. The result was a high starting torque motor, utilizing double squirrel-cage windings in the rotor and a small compact magnetic starter actuated by push button, pressure gage, float switch or other means.

Simplicity of the combination of motor and starter for full-voltage starting led immediately to the development of a moderate torque motor that could be started on full voltage. The indications are that this motor will rapidly replace the usual type of squirrel-cage motor, which requires reduced voltage starting. This replacement will apply up to ratings of 25 hp. for general applications and probably up to 50 hp. for large industrial plants where high starting currents are not objectionable.

These low-starting-current motors with their small compact controls are particularly advantageous for application to many machines, particularly machine tools and the like, where it is desirable to mount the control on the machine but where space requirements are limited.

The advantages of this arrangement over the usual type of squirrel-cage motor with reduced-voltage starter are lower first cost, simpler more compact and better appearing installation and lower maintenance.

The appearance and the external dimensions of the so-called "full-voltage-start" motor are the same as the squirrel-cage induction motor of the usual type.

Development of the totally inclosed fan-cooled motor was probably brought about by demand for motors having greater reliability under severe physical operating conditions, such as dusty or dirty locations and in places where there were hazards because of dripping or splashing of oil, water or weak acid solutions. Some of the common applications are in flour mills, grain elevators, grinding and paint rooms, particularly in automobile plants, chemical plants, engine rooms, gas plants and the like, and on coal-handling machinery, conveyors and stokers.

Standard lines of totally inclosed fan-cooled motors are available for alternating-current single-phase and polyphase power circuits. The adoption of this design has made available lines of motors that can be applied under adverse physical conditions with certainty of low maintenance and minimum hazard.

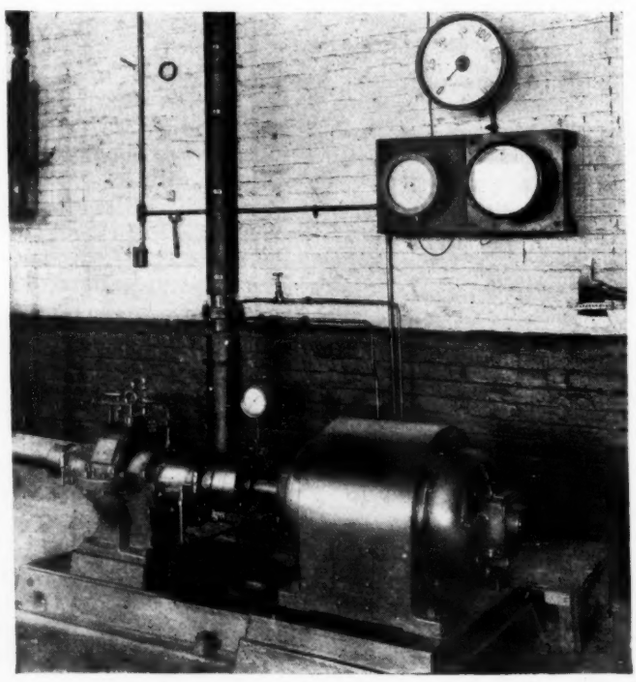
Various details of mechanical construction have been employed by different manufacturers of this form of motor, but at least one line of totally inclosed fan-cooled motors have been developed that are mechanically interchangeable with the open-type motor of the same rating.

Fig. 3 shows another construction of the totally inclosed fan-cooled form rated 25 hp., which is driving a pump in a gas plant where the dust conditions are severe.

Synchronous Motors

The premium placed by central-station companies on improvement of power factor, along with other inherent advantages, has greatly stimulated the development of synchronous motors and a point has now been reached

Fig. 3—Totally inclosed induction motor driving pump for hot-water seal on gas holder



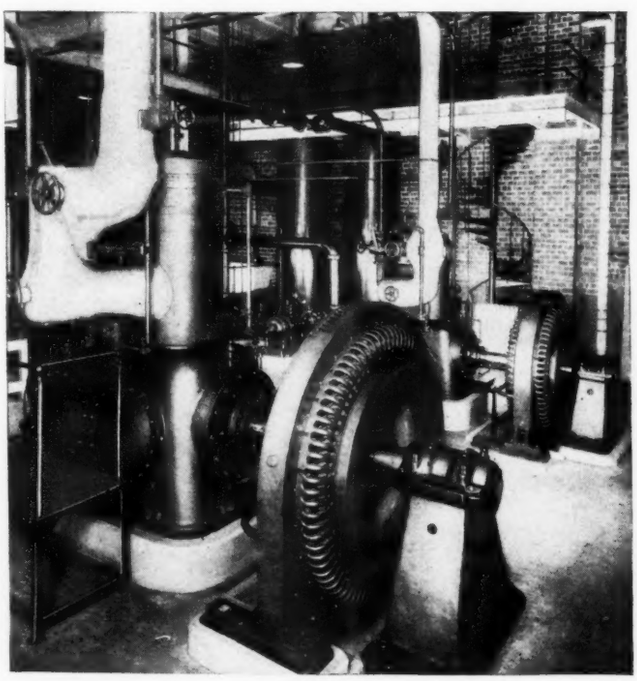
where synchronous motors can be considered for practically all constant-speed applications involving motors 25-hp. and larger. The synchronous motor becomes more attractive as the size increases, because the cost differential is relatively less and the possibility of power-factor improvement with a motor of large capacity is greater.

Probably the outstanding development in synchronous motors is a line of general-purpose motors paralleling and built in the same frames as the squirrel-cage induction motors. These motors may be applied wherever squirrel-cage induction motors are applied, and a control equipment is available which makes it possible, so far as the operator is concerned, to start these motors either manually or automatically, exactly as squirrel-cage induction motors are started. Fig. 2 shows one of these motors driving an air compressor.

There have been other developments in the design of synchronous motors whereby greater starting torque is obtained, which has made it possible to apply these motors to loads requiring full-load torque or more. The starting current of these high-torque motors may be objectionable in some locations, and the driven load may be such as to make it desirable to apply the torque gradually. Two or three types of synchronous motors have been developed, particularly for low speeds and high power ratings, which permit the motors to start up light with low starting current. After being synchronized, the load is brought up to synchronous speed by means of some sort of a clutch mechanism.

There have been many other improvements in mechanical design of synchronous motors, such as welded frames and rotors, which have no particular bearing upon the application, but which are of interest from a mechanical viewpoint. Two of these motors directly connected to ammonia compressors of the vertical type are shown in Fig. 4.

Fig. 4—Two 100-hp. synchronous motors directly connected to vertical ammonia compressors



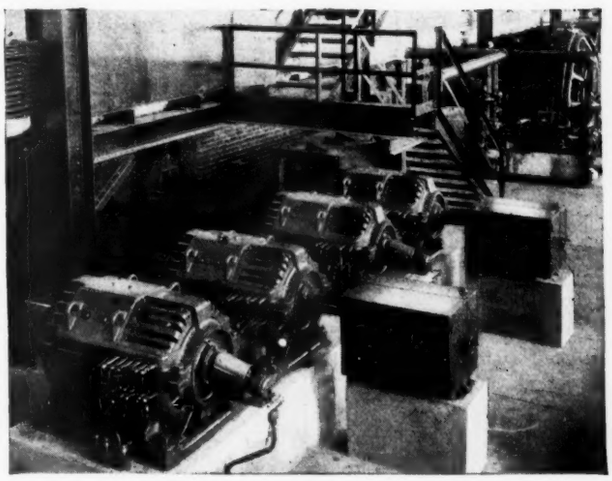


Fig. 5—Four 190-hp. 300-volt direct-current motors, connected two in series, driving two rotary metal shears

The synchronous motor can be designed for low speeds to better advantage than any other type of motor; that is, without so adversely affecting first cost or efficiency. For these reasons the tendency is toward direct drive, with a view of obtaining a more compact and simplified installation presenting a better appearance and requiring a lower maintenance.

Direct-Current Motors

Strange as it may seem, the use of direct-current motors is on the increase, as this type of motor, with its control, offers refinements in speed and torque control which are not obtainable with other types. As a result, many machines formerly driven by steam engines direct or through complicated adjustable-speed transmission systems are now driven by direct-current motors. The recent developments consist in refinement of characteristics, development of mechanical features for heavy duty or unusual operating conditions and, probably most important, the development of control whereby the inherent advantages of the direct-current motor may be fully realized.

A good illustration of one of the recent improvements is the paper machine drive shown in Fig. 1. Each direct-current motor drives a section of the paper machine through herringbone gears, while its speed regulator is chain-driven from the outboard end. The motors are totally inclosed and pipe ventilated, the whole installation being made with a view to reliability and safety under severe operating conditions and unusual requirements as to performance.

A new heavy-duty motor with low flywheel effect to permit rapid acceleration, which was designed to meet the recent specifications of the Association of Iron and Steel Electrical Engineers, is shown in Fig. 5. These motors drive rotary shears in a steel mill, and the application is novel in that the control automatically synchronizes the speed of the motors with the delivery speed of the metal passing through the shears.

These specific applications, and many more that could be cited if space permitted, indicate that the user is making great progress toward obtaining the full advantage of electric drive by choosing the electric motor to suit the job.

The Fundamentals of Modern ELEVATOR SERVICES

By Bassett Jones
Consulting Engineer, New York City

THE modern building is a machine. To be successful, first it must work properly. It must meet efficiently the demands made upon it. The ratio of its output to its input must be a maximum considered in relation to its economic life. Just like any other machine it must render a service, and just like any other machine, it must render this service against a head of fixed charges—interest on the money invested, depreciation, maintenance (including taxes), and that often forgotten item, obsolescence. The service the building renders is measured in dollars. Part of this service, the service of appearance, is primarily a matter of how well the building is proportioned to its functions as a useful thing. This, I have been taught to believe, is the underlying principle of applied art, including architecture.

Unless the public will exchange enough dollars for the service a building can render, it is a foredoomed failure. The measure of the intelligence of those responsible for the design and construction of the building is spelled PROFIT. Unless it can be demonstrated that the proposed building will make a profit on the investment, wise holders of money will not lend their dollars, and thus society automatically protects itself against waste. The building is not built.

Within the last decade or score of years urban society has sought to protect itself against the encroachments of the naturally predatory individual in many ways. One of these is the enactment of the so-called zoning laws, which are designed to limit the loss of natural light by the ever-increasing height of buildings with increasing taxes and building costs. For, as costs of construction and operation increase, more and more "yield area" must be built on each square foot of ground area to hold the increment of profit to a required amount in competition with other sources of profit.

The desirability of thus concentrating yield area in large blocks is the result of a natural concentration of the people constituting a business society within easy reach of one another. Until it *pays* society to do otherwise, we shall continue to pile two bricks on the place where one brick stood before.

The Author Says

THE modern building is a machine. The measure of the intelligence of those responsible for the design and the construction of the building is spelled PROFIT. Unless the public will exchange enough dollars for the service a building can render, it is a foredoomed failure.

The zoning laws presented a new problem to the architect, to the engineer and to the builder, the solution of which is still far from perfect. It demanded the economic reorganization of building design, plan, equipment and construction. So far, the solution is presented in our towered cities. The law demands a decreasing yield area per floor with increasing height. The natural reaction was to increase the number of floors, to seek for cheaper methods of construction and to devise service equipment that occupied a smaller part of the gross area. Thus only, could yield area sufficient to pay a profit on the investment be obtained within the obvious limitations of construction costs. Hence, eleven floors were sandwiched in where ten floors lay before. Ceiling heights were cut, floor thickness reduced. Then appeared the four-inch floor slab with exposed beams. Fill is reduced to the utmost limit. In order to reduce building costs, the flimsiest and cheapest materials that will last out the ever-decreasing obsolescence period are employed. Haste in construction to save the fixed charges on land and investment becomes the order of the day. A new school of architects and builders has come into existence.

With this increase in height of buildings and number of floors built on a relatively restricted ground area, the problem of vertical transportation became acute. How are all these people first to be handled on the ground floor and, second, be carried comfortably and expeditiously to the area and floor for which they pay high rents? If this transportation service does not meet their needs, fancied or real, possible tenants will rent elsewhere. Either this or the yield of the buildings must be reduced until tenants will come in spite of the slow transportation. Thus another competitive field is opened up, and the vertical transportation system has become a real factor in building plan and in its economic success. As time goes on, the elevator system is certain to become a primary element in building design and must be determined upon while the plans are in their elemental stages —not only this, but determined in view of all the demands that may be made upon it both present and future.

Before any layout of the elevator equipment of such

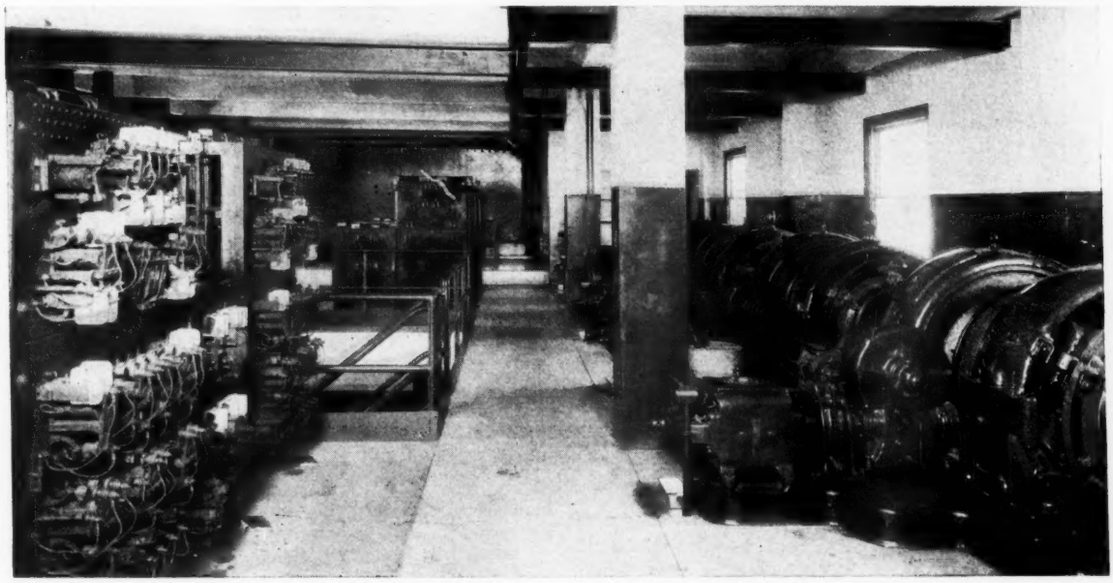
buildings is possible, a careful study of the service requirements is necessary. How many people will occupy the building both initially and in the future? What sort of people are they and how do they do business? How many visitors will they have? With what kind of elevator service will they be satisfied? The answer to these and other similar questions must be had before the layout problem can be approached.

After the character and quantity of service required have been set up for arrival, transient, lunch and the departure periods, and the heaviest load interval determined, then it is possible to begin the actual calculations that determine number, size and shape of cars and their proper arrangement in banks. In general, each building is a problem in itself and must be treated on its own merits. Too much attention cannot be paid to the size and shape of the cars. The elevator service in many buildings is poor because the column spacing has been so arranged that the proper cars cannot be installed.

The number of cars required to maintain the desired service in each bank is a function of the round-trip time. The round-trip time depends on the number of passengers handled, on the number of stops, on the passenger movement time, on the time required to operate car gates and landing doors and on the average speed maintained. The speed depends on the rated speed of the equipment used and on the acceleration attained. Passenger-movement time is dependent on ease of ingress to and egress from the cars, hence on the number of passengers in the car, on the car entrances and on the adequacy of the corridor plan. So important has this matter become that great attention has been paid to means for attracting the waiting passenger's attention.

Much study has been given to car gates and landing doors in the effort to increase the speed of operation. The collapsible scissors-like car gate, when power driven, has proved a dangerous affair and is fast giving way to solid car doors. With the increase in speed of door operation attainable continuously only with power operation, the forces applied by the operating devices are considerable and call for a sound mechanical design and construction of the door, its supports and its guides. The door panels must be light but rigid, and supported accurately in line throughout their motion with a minimum of friction. Radical departures in the design of hangers and guides have resulted from these demands. The door unit has become a shop-assembled affair built to templet with the tolerances usual in machine work. In fact, the landing door has become an integral part of the elevator equipment and is often included in the elevator contract, where it belongs.

Long research has led to means whereby the speed of the car itself and its acceleration may be comfortably and safely increased. All of this leads to a reduction in round-trip time and hence to a reduction in the number of elevators required. Or, what is the same thing, that the same number of elevators can serve more floors.



Motor-generators for variable-voltage controlled elevator machines, set on vibration-proof foundations

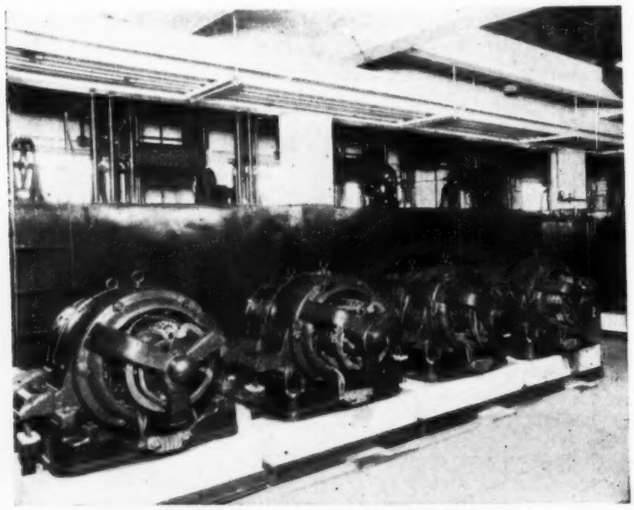
Of course all these improvements cost money, but when we consider the space sacrificed to run one elevator through twenty or more floors and the cost of providing this space, including hoistway, corridor area and finish, and landing doors, the money may be well spent.

It seems quite obvious that when an important element in the success of the building is so closely bound up with the plan of the building, this element should be studied out with the plans. Just as soon as the general plan based upon the available investment has been sketched out sufficiently to permit traffic determinations, the elevator equipment should be settled and incorporated in the sketch plans. Such a study may show the economic fallacy of the design or it may lead to a possible extension of the building that will increase the operating profits. Generally, several such studies, proceeding with the sketches, are necessary to determine just how many floors can be economically incorporated in the building, considering the elevator equipment available and its cost.

Furthermore, with increased speeds and automatic power-operated doors and other devices, greater hori-

zontal clearances are required, which should not be taken out of the car area. Longer overhead and bottom run-by space is necessary and deeper pits. Reactions on the supporting steel are increased. Of all this the planner must be informed before the building has developed to a point where necessary changes are expensive or difficult to make without altering the building design.

Adequate hoisting-engine rooms are a necessity. So much important and costly machinery requiring high-grade maintenance, deserves a better fate than being crowded into a poor operating arrangement merely that



Upper level of a well-arranged elevator machine room

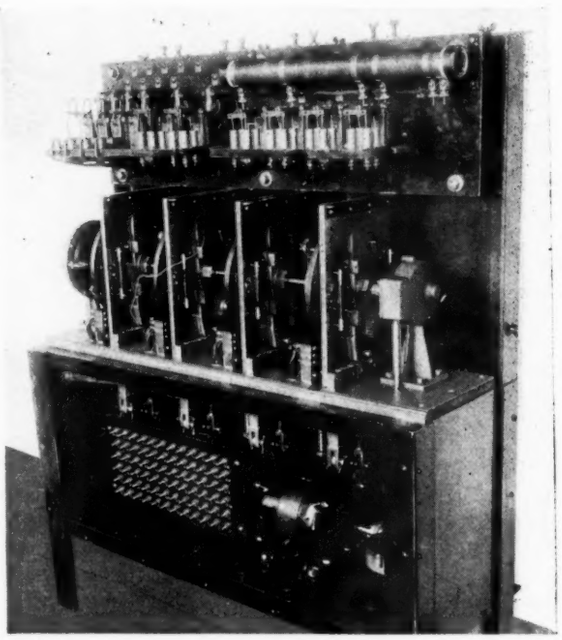
a roof may look just so. Proper lighting and forced ventilation of the hoisting-engine room is essential.

An obvious answer to the difficulty of providing elevator service in high buildings is to increase the speed of the cars. But this introduces a difficulty in that when the rated speed is increased much over 700 ft. per min. and the acceleration and retardation correspondingly increased, the operator's eye, mind and hand cannot co-operate properly in the short time available, and the number of false stops is unduly increased, which increases the round-trip time by an amount far in excess of the intended saving.

Hence, with the coming of the zoned building the elevator industry was faced with a new problem, which has and is resulting in the design of practically automatic elevators running at rated speeds up to 1,000 ft. per min. and accelerating comfortably at rates far in excess of any thought possible with the older methods of control. The landing doors and car doors for such elevators are power driven at high speeds and are operated automatically from the car, so that the operator has little to do other than register calls by passengers and police the car. Calls from landings are automatically registered and the car stopped at the landings in proper sequence independently of the operator.

With such elevators it is possible to render excellent elevator service economically in zoned buildings of up to about 40 floors, but above this point the limitations of change of air pressure due to speed that the passenger can stand, and the effect of high rates of acceleration, even if smoothly attained, on the passenger's body, limit the possibility of attaining the desired result without a serious curtailment of yield area due to the number of elevators required. If it is ever found necessary and economically sound to construct a zoned building of much over 40 floors, and in which anything approaching good elevator service to the upper floors is required, it will probably be necessary to operate two elevators in a common hoistway, one over the other, local below and express above. For this purpose it will be necessary to double-deck the ground floor, giving two bottom terminal entrances, one over the other. Indeed, it is questionable whether the peak traffic in a building of large total yield area, such as this, can be properly handled in the available corridor space on a single ground floor. Several buildings of 80 floors, and even more, have been projected during the last few years. Should one of them ever be erected on any rational basis of economy, we shall see some such radical departure in elevator arrangement employed, for the limitations of speed and acceleration in vertical passenger transportation are now known.

Elevator traffic in the modern many-floored zoned building has become much like railroad traffic. Cars



Automatic dispatcher and schedule machine

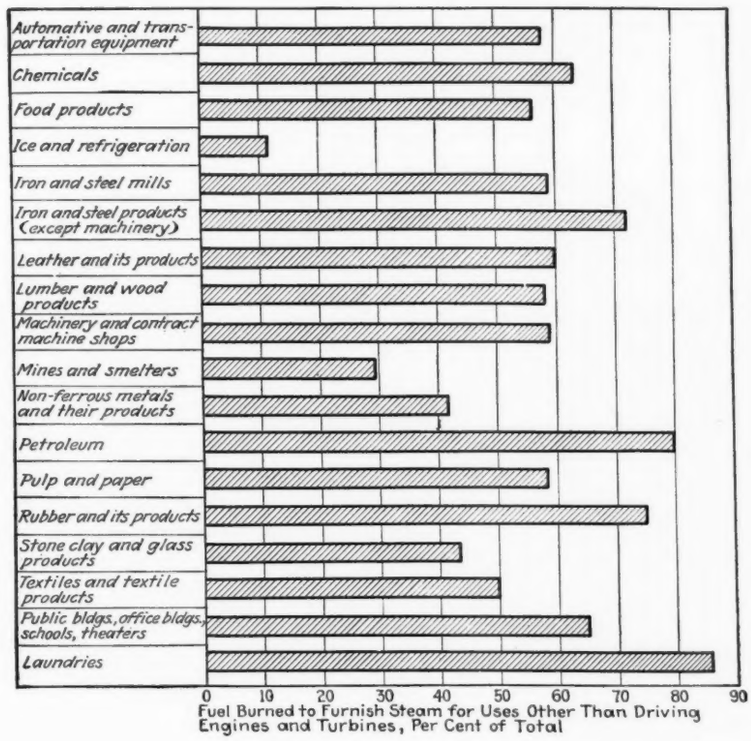
Such devices are necessary where the cars must be held closely to schedule. The machine is adjusted by switches located at the starter's station.

leave and run on fairly close schedule, automatically bypass landing calls if fully loaded, and are kept reasonably well spaced both automatically and by automatic signal devices that keep the starter informed of car position. The starter has to assume the duties of a train dispatcher, and in buildings where his ordinary work alone keeps him busy, a separate car dispatcher is employed.

Such elevator developments have naturally led to a careful study of safety resulting in the design of new, and redesign of old equipment, to the point where it can be said that the modern automatic high-speed passenger elevator is much safer than any other elevator that has ever been built.

Census Report on
PRIMARY ENERGY
Does Not Tell Whole Story

What "Primary Power" Omits


Automative and transportation equipment
Chemicals
Food products
Ice and refrigeration
Iron and steel mills
Iron and steel products (except machinery)
Leather and its products
Lumber and wood products
Machinery and contract machine shops
Mines and smelters
Non-ferrous metals and their products
Petroleum
Pulp and paper
Rubber and its products
Stone clay and glass products
Textiles and textile products
Public bldgs., office bldgs., schools, theaters
Laundries
0 10 20 30 40 50 60 70 80 90
Fuel Burned to Furnish Steam for Uses Other Than Driving Engines and Turbines, Per Cent of Total

The United States Census of Manufactures' definition of primary power neglects over half of the fuel burned under boilers in industrial plants

THE term "primary power" as applied to the manufacturing industries has for some years included counts of power derived from steam and internal-combustion engines, steam turbines, waterwheels and motors driven by purchased current. The totals have been set up as the total of primary power and have been accepted by a majority of equipment manufacturers as a complete measure of the power picture. The figures have been used to measure markets for these manufacturers, and doubtless have been of considerable assistance, even though they do show less than one-half of the fuel actually burned for power and process uses.

The point in mind is illustrated by the reply received from one manufacturer to a request for inventory counts in his power plant. In this reply the manufacturer stated that, while he had no power plant, he was filling in the counts on those items of equipment which made up a steam generating outfit that he had installed to drive a number of steam hammers. Examination of the returns showed that actually he had a beautiful set-up of pulverized coal-fired boilers and was generating and applying steam to his hammers and plant to the extent of approximately 175,000 lb. per hour. And this is just one plant.

Obviously, there is an important factor to be added to the figure of primary horsepower, in order to have the whole picture. Accordingly, *Power* selected 600 plants distributed through all the industries, and asked these plants to name the proportion of fuel burned primarily to drive prime movers as defined by the United States Census and the amount burned to generate steam for other purposes. The results are shown by industry divisions in the chart. The average, 56.9 per cent, represents the portion of total fuel used for steam generation not taken into account in the present Census prime mover figures.

INDUSTRIAL POWER SERVICES

Assume Added Importance

INDUSTRIAL power has assumed added importance during the last few years. This is traceable in part to greater mechanization of industry and in part to an awakened appreciation of possible savings which, under present competitive conditions, may go far toward maintaining dividends.

> Higher pressures have opened up a wider field for the turbine of the high back pressure and bleeder types.

During, and for a period following the War, the fuel situation was a large factor in the shutting down of industrial power plants; some wisely, others unwisely. Of late, however, there is a noticeable reaction toward solution of each case on an economic basis in the light of improved equipment now available. This has resulted in the installation of many new plants and the rehabilitation of old ones where the demand for process or heating steam is appreciable, and the purchase of electricity where the steam demand is small. In many cases a combination of generated and purchased power has pointed the way to the best heat balance, and in some large installations an exchange of power with the central station has been effected to mutual advantage. Such interconnection is now being looked upon more favorably by a number of central-station companies than was the case a few years ago.

> Over 60 industrial plants employ pressures of 300 lb. or more; half are over 400 lb.; one is 800 and another 1,000 lb.

Taking advantage of the tremendous advances in power-plant practice fostered by central stations in their efforts to attain increased efficiency and increased unit outputs, many of the more important industrial plants have adopted higher steam pressures, heat-reclaiming devices, automatic regulation, improved methods of burning fuel, etc. The higher steam pressures have made possible the employment of high back-pressure turbines exhausting to process at pressures formerly necessitating live steam.

These refinements have necessitated the employment of more highly trained power executives, men not only possessing a background of practical and technical experience, but capable of thinking in terms of plant economies covering the various power and steam services as well as power generation.

Many industrials are now putting in larger boiler units or rebuilding old boiler settings to permit higher rates of steaming. Both pulverized coal and stokers of improved design are being employed. For a time there was a decided trend toward pulverized coal, partly because of its relative newness commercially, and partly because many looked upon it as a panacea for fuel-burning difficulties. The number of such installations, mostly of the unit type, is variously estimated at several hundred to nearly a thousand. Experience with some hasty and ill-considered installations has led engineers to a more rational viewpoint, and as a result there is now more general recognition that both stokers and pulverized-coal systems have their place in industrial power plants according to local conditions.

> The more important industrial plants have adopted higher steam pressures, heat reclaiming devices, automatic regulation and improved combustion methods.

Air-cooled furnace walls are being employed extensively in the medium-sized plants. The water wall is finding its greatest application in the bigger high-output plants, because of greater cost.

Air preheaters are no longer regarded as exclusively central station equipment but are finding an important place in industrial plant design not only in stoker and pulverized-coal plants, but also in a number of existing hand-fired plants where they have been able to effect substantial savings.

Along with improved boiler practice have come improved methods of coal and ash handling. Higher rates of pay for unskilled labor have undoubtedly been a large factor in industrial plants adopting the mechanical and hydraulic methods for handling such materials.

Available statistics indicate that there are over sixty industrial plants employing steam pressures of 300 lb. or more; half of these are over 400 lb., one is 800 and another 1,000 pounds.

These higher pressures have opened up a wider field for the turbine of the high-back pressure and the bleeder

types. One difficulty that is besetting turbine builders as a result of this is lack of standardization in back pressures and bleeder pressures, as a result of which practically every one of these turbines is a special job.

With two or three exceptions the steam engine has not invaded this field of higher pressures, but in the range of 200 lb. and under, the number of steam engines, especially of the uniflow type, going into industrial plants is appreciable. Indications point toward engines of higher speeds for such service.

The trend toward higher steam pressures has been responsible for many accessory manufacturers developing new lines to meet these conditions, such as steam valves, blowoff valves, traps, gage glasses, etc. It has also necessitated closer and more scientific attention being given to the treatment of feed water.

The outstanding forward step in the industrial use of steam has been the successful adoption of high pressures for process work. Formerly, the industrial processes using steam were largely of a heating nature, and lower pressures, seldom exceeding 350 lb. per sq.in. were the highest used. Where higher temperatures were required, it was customary to use some other heating medium, such as heated oil, or electric heat or the heat of combustion.

Recently, however, processes have been introduced requiring high pressures, either alone or in combination

As knowledge of the performance of new designs of belts spreads, a much wider application of short-center belt drives may be expected.

with high temperatures. This has made necessary the adoption of high-pressure boilers, in some cases with working pressures of 1,000 lb. per sq.in. and over.

The processes using these pressures and temperatures are largely found in the manufacture of chemicals, particularly synthetic chemicals. Some, however, are found in other industries, such as the making of fabricated building materials. An example of a high-pressure installation is the plant of the Mason Fiber Company, Laurel, Miss., using 1,000-lb. steam.

Complete automatic control for process steam installations, in which the demand of the process for steam is the controlling factor, is now being worked out. In some plants this is meeting with much success, and its rapid extension can be looked for. For example, one large manufactured gas plant, feeding steam to its water-gas generators from a common header, controls the pressure in this header, so that the steam is supplied to the generators at constant pressure although the demand fluctuates widely. The result has been satisfactory, giving economy of fuel and labor and resulting in better gas generator operation.

Steam accumulators are finding wider usefulness in industry than in the past. This equipment was first widely used in paper mills and was later applied to gas manufacture. In the last year a successful accumulator installation has been made at a sugar refinery, where it is used to store steam bled from the turbines for the purpose of heating the evaporating pans. Here it forms a convenient storage between the constantly operated turbines and the intermittently operated evaporators. This advance of the steam accumulator into a new field undoubtedly forecasts still other advances into industries

Complete automatic control for process steam installations is now being worked out successfully in several plants.

where it is not yet used. In fact, an accumulator installation is now being made at a mine, and operating results from this new installation are awaited with interest.

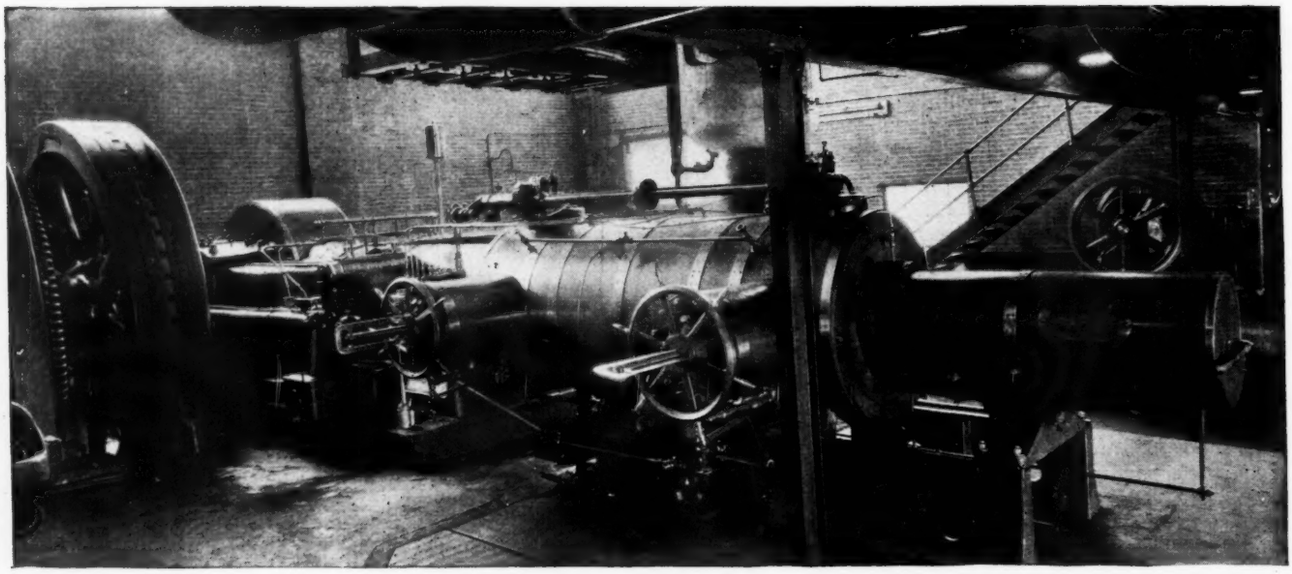
The last year and a half have seen rapid strides made in the application of compressed air in material handling. Pneumatic conveying, the moving of materials through a pipe line by air pressure, has been used for a long time on such materials as grain and fertilizer. More recently, its use has extended to the handling of materials used in the soap, paper and ceramic industries. In addition to the advantages realized from a handling point of view, the air compressor can be operated by a synchronous motor, improving the plant power factor. This latter factor, in addition to flexibility and convenience, has led to the use of compressed-air motors for driving mechanical conveyors, thereby replacing a number of small induction or direct-current motors with one or two large synchronous motors and increasing the plant power factor in this way.

The transmission and application of mechanical power have seen the introduction of no new designs of importance during the last year. There is, however, one trend of importance in this field that deserves mention. While gear and chain drives of various types keep their well-deserved popularity, the fad for the direct connection of motors to machines is passing, and the practice tends to be found only where fully justified. In place of this direct connection, improved short-center belt drives of both the grooved- and flat-pulley types are finding wider application. The development, two or three years

The last year and a half has seen rapid strides made in the application of compressed air in material handling.

ago, of several new types of belts has made this change in practice possible. As knowledge of the performance of these belts spreads, a much wider application of short-center belt drives may be expected.

Speed reducer designs have been greatly improved during the last fifteen months. The newer are more nearly silent, use better materials and have improved lubrication. Consequently, higher efficiency and longer life are being realized.



A uniflow in a paper mill operating against available back pressure

New Designs for

BLEEDING STEAM

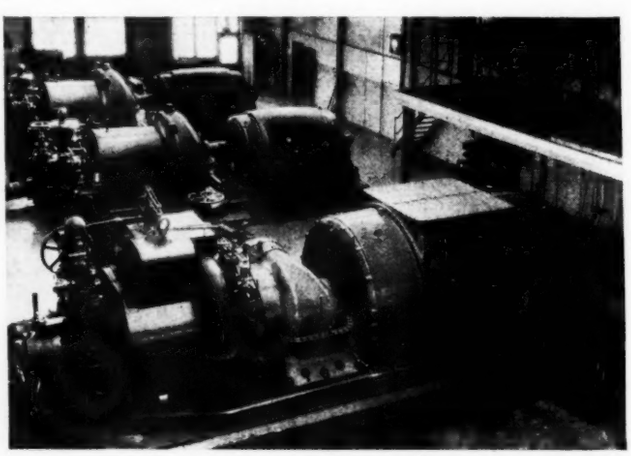
Reduce Industrial Power Costs

STEAM, owing to its peculiar properties, is the most widely used heating agent today. Office buildings, hotels, industrial plants are steam heated almost without exception. In addition there are many industries, such as paper and textiles, which rely on steam for their heating processes. As the temperature of steam is a function of its pressure, heating pressures vary widely. In most cases heating and power demands are to be satisfied simultaneously, and it is again due to the peculiar characteristics of steam that it can be used to fulfill both these requirements satisfactorily.

In many cases heating requirements predominate to such an extent that the power needed can be generated on a bypass principle, by running part of the steam through a turbine or engine which exhausts into the heating system. Power, in this case, is strictly a byproduct and its nominal cost is a function of fixed charges only, most of the heat going to the process.

Fig. 1—Bleeder turbine in alkali plant, operating at 200 lb. initial pressure and 28½ in. vacuum

Capacity is 6,250 kw. and 85,000 lb. steam per hour at 3 lb. pressure are bled automatically.



On other occasions, however, power demands exceed heating requirements, or in other words, only part of the steam used for the generation of power is needed for heating. While it would be feasible to generate such steam in a separate boiler at heating pressure, a balance sheet will disclose the fact that it is more economical to generate all the steam at as high pressure as is desirable and expand it down to the heating pressure in a turbine or engine, or in other words, extract the heating steam from the prime mover after it has performed

work in such machine. If the heating pressure is higher than the exhaust pressure of the engine, such process is termed "bleeding." The economic aspect of the bleeding process is based on the quality of water vapor which permits of obtaining high pressure with but little more expense of heat than is required for low pressure.

From the foregoing it follows that bleeding is restricted to cases where power demands predominate over heating requirements. Because only the amount of steam admitted to a prime mover can be extracted and whenever the rate of steam flow required for power generation is below that of heating demands, makeup steam has to be admitted through a reducing valve. However, as will be shown later, a variation in rate of heating steam from zero up to full power flow can be handled by bleeding.

Bleeder units may be either turbines or reciprocating engines. The automatic bleeder turbine with pressure-regulating device has been known in industry for a number of years and is now quite widely used. Fig. 1 shows a typical installation of such a turbine in the power plant of the Pennsylvania Salt Manufacturing Company.

Bleeder-type engines in general comprise control mechanism to furnish automatically the desired amount of heating steam as a function of its pressure. In other words, all controls regulate for a constant pressure in the heating line. If the rate of flow in the heating main increases, the pressure will drop slightly and the control will compensate for this by admitting more steam. Therefore, a certain pressure drop is required with any bleeder control to cover the range from minimum to maximum flow, similar to the difference of speed of a centrifugal governor for its load range. Such pressure drop can be held within very narrow limits.

Two-stage, or compound, engines, so far, have mostly been used to effect bleeding, because the heating line can be connected to the receiver, and the necessary control is limited to the low-pressure cylinder. It was customary to operate the engine condensing and select a receiver pressure which would fit the heating requirements. This is an arrangement which works out very well; it has, however, the drawback that during periods of high heating demands the engine cannot carry full load, because the low-pressure cylinder runs practically idle. As the cylinder ratio of bleeder-type engines, however, is small, ratios down to 1 to 1 having been used, the high-pressure cylinder is capable of delivering a good deal more than half the rated power of the machine. Under this condition of maximum steam flow the lubrication of the low-pressure cylinder becomes a matter of difficulty and it is necessary to maintain a minimum cutoff in this cylinder of 5 to 6 per cent to insure lubrication. This steam, being exhausted into the condenser, entails a certain loss.

Control of the low-pressure cylinder can be effected in different ways. The simplest method is to interpose a throttling valve in the steam inlet to the low-pressure cylinder and a similar valve in the heating line, as shown in Fig. 4. These valves can be controlled by a single mechanism, preferably an oil relay, and are connected so that as one opens the other closes. The low-pressure valve gear is, in this case, set for a fixed cutoff. As this method controls by throttling, it is subject to the shortcoming of all throttling devices. It has, however, some practical value because it can be applied to existing engines. A better way consists in providing a cutoff control for the low-pressure cylinder which regulates for constant receiver pressure. This can take the form of a spring-loaded piston moving in a cylinder which is connected to the heating line; or, as is necessary with valve gears requiring considerable force, comprise a pilot valve with oil relay and follow up motion.

This mechanism influences the low-pressure cutoff only, the high-pressure cylinder being under control of a speed governor. Naturally, during periods of fluctuation in heating steam or power demands, these two controls cooperate to maintain the heating pressure and engine speed at the desired values. It is also practical to reverse the method of control and influence the low-pressure cutoff

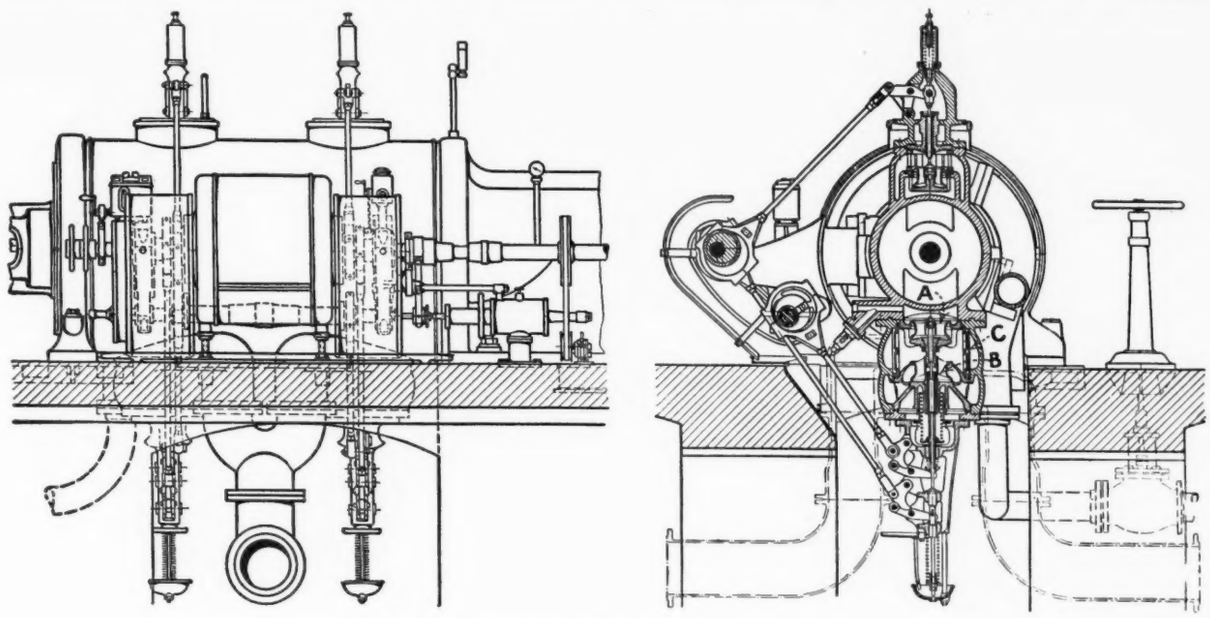


Fig. 2—Bleeder valve for simple engine

by means of a speed governor and have the heating pressure regulator act on the high-pressure cutoff. The tendency in this case also will be to regulate for constant heating pressure and engine speed. While bleeding controls as applied to compound engines are widely used, still the superiority of the single-stage expansion engine in medium sizes is such that equal, if not better, results can be obtained with such machines.

A connecting link between the compound and the single-stage bleeder engine is a single-cylinder compound engine which uses the crank end of the cylinder as high pressure or first stage while the head end represents the low-pressure cylinder, the nominal cylinder ratio being 1 to 1. The engine has a unique control in that high-pressure compression and low-pressure cutoff are influenced by a pressure regulator, while the high-pressure cutoff is accomplished by means of a speed governor.

Two double-beat exhaust valves, as in Fig. 2, are located at each end of the cylinder, arranged in series, and in addition automatic check valves *C*, of similar type to that used with air compressors, control the flow of steam from the space between the two valves to the bleeder line. Each exhaust valve is equipped with independent gear, the valve closest to the cylinder controlling release and giving a fixed compression of about 10 per cent; the other valve has variable timing controlled by a pressure regulator and is capable of a range of compression from 100 down to 30 per cent. The bleeding steam is ejected from the cylinder during the exhaust stroke; it expands and is recompressed up to bleeding pressure and passes the inner exhaust valve, past the check valves, into the bleeder line. At 100 per cent extraction the outer exhaust valve remains closed and all steam admitted to the cylinder is recompressed and pushed into the bleeding line.

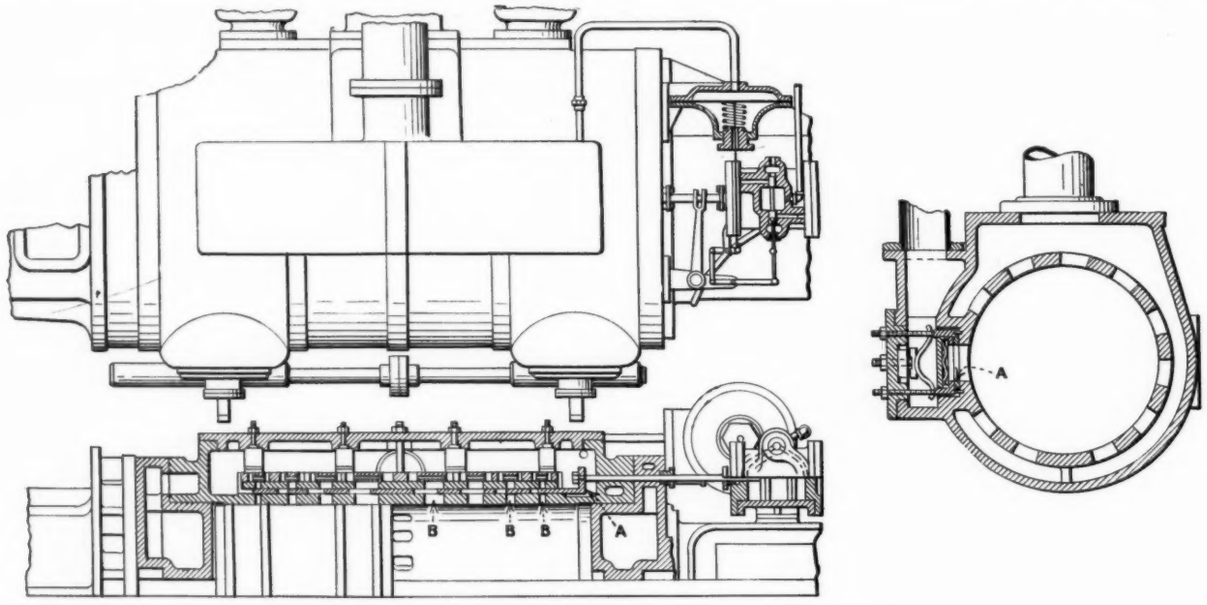


Fig. 3—Gridiron bleeder valve of the Skinner design

The effect of this method of control is a varying effective cylinder ratio depending upon the rate of bleeding. Under certain conditions this engine approaches a single-acting engine and requires a correspondingly heavy flywheel. It constituted the first attempt to incorporate bleeding in a single-cylinder engine.

Another form of single-stage engine employs one cylinder end for bleeding, the cutoff of which is under control of a pressure regulator; while the other cylinder end, with speed governor control, exhausts into a condenser or against other suitable back pressure. The speed governor, naturally, is interlocked with the pressure control so as to prevent overspeeding in case the load should be reduced unduly.

The last two types of engines, while being single-stage, have the drawback of the compound engines in that during periods of small bleeder-steam demand the power output is reduced to a large degree. This disadvantage has been overcome by a recent design of single-stage bleeder engine, and the means to accomplish this comprise a special exhaust-valve arrangement, brought out by Bauart Starke & Hoffman, Germany.

If the demand for bleeding steam decreases, the outer exhaust valve begins to open to permit part of the steam to escape into the condenser, and owing to the delayed recompression the amount of steam ejected into the bleeding line is reduced. The main advantage of this design is that the engine is capable of carrying full load irrespective of the rate of bleeding and that no lubrication difficulties can occur as is the case in compound engines. Furthermore, at the 100 per cent rate of bleeding, all steam is ejected into the bleeding line. The exhaust valve gear of such an engine is rather complicated and costly, but as it is a single-cylinder machine, its total cost will be less than that of the equivalent compound engine.

The engines so far described are all of the counter-flow type. A good deal of thought has been given to the problem of incorporating bleeding mechanism in uniflow engines. Owing to the separation of the two cylinder ends it is possible to bleed a certain amount of steam during the expansion stroke by means of check valves located a certain distance from the exhaust ports. The amount of steam so bled is dependent upon the load the engine carries and at light loads is small.

Professor Stumpf showed by theoretical analysis that with the bleeder ports located at a point in the barrel 0.35 of the stroke from the stroke end, the bleeder pressure could be from 18 to 35 lb. gage, with 150 lb. gage pressure. With the ports located at mid-stroke, the bleeder pressure could be as high as 57 lb. Furthermore, his calculations were based on higher release pressure and atmospheric exhaust. For obvious reasons it is desirable to run the engine condensing if possible. This method appears practical only for purposes of feed water heating. For bleeding larger quantities of steam studies have been made on combinations of auxiliary exhaust valves, check valves back of the auxiliary exhaust valves and an additional valve in the central exhaust. This last valve opens and closes for every stroke of the engine. When this valve is fully opened during the period of central exhaust, the engine operates as a regular uniflow engine. If this valve is maintained closed during this period, all steam, after having expanded, is recompressed in the cylinder up to bleeding pressure and is ejected through the auxiliary exhaust and the check valves into the bleeder line.

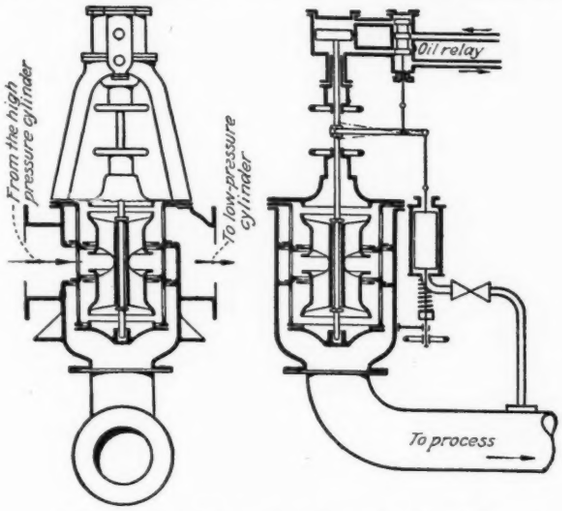


Fig. 4—Double-beat valves for bleeding

This mode of operation represents 100 per cent bleeding. By varying the closing point of the central exhaust valve, a greater or less quantity of steam will escape and, similarly, a less or greater quantity will be ejected into the bleeder line. The auxiliary exhaust valves, owing to their timing, maintain a uniform final compression in the cylinder which is so important for economy.

A number of years ago the Skinner Engine Company made some studies along similar lines for use on its uniflow engine, bleeding through the auxiliary exhaust valves and with the central ports exhausting to the condenser. With the lower release pressures and the lower expansion line in the cylinder it was found that there was a wide variation in the amounts of steam that could be bled if the bleeder ports were fixed in their position with relation to the stroke, and if the load on the engine varied greatly. The company then devised a method of shifting the bleeder ports by means of a grid valve *A* with successively widening ports registering with corresponding ports *B* throughout the length of the cylinder, as shown in Fig. 3. The grid *A* is controlled by a back-pressure diaphragm and is shifted forward or backward lengthwise with the stroke, thereby creating the opening near the beginning of the stroke when the load on the engine is light and near the end of the stroke when the load on the engine is heavy.

During recent years a certain change seems to have taken place with regard to the definition of what constitutes an economical engine. It gradually was found that low water rate is not the only measure for economy, but that weight, floor space, total cost and endurance qualities are equally important. Considerations of this sort have led to the belief that arrangements of parts which will produce a more balanced engine will permit of an increase of rotative speed as well as piston speed and thereby will, for certain power output, reduce all the items enumerated above. The result of attempts of this sort are engines of the vertical type employing a plurality of cylinders.

While the development of this type is still in an unsettled state, attempts have been made to use such engines for bleeding. The method carried out so far comprises means for switching individual cylinders from bleeder line to condenser and vice versa, according to the demands for bleeder steam. The mechanism necessitates one individual valve in the exhaust of each cylinder, which valves, as well as auxiliary valves to change clearance, can be operated by a control under influence of the bleeder pressure. A unit of this type built by the Chuse Engine Company appears in Fig. 5. The steam inlet to all cylinders, of which there are six, is controlled by a speed governor as in an engine without bleeding. Engines of this type should be able to carry full or overload irrespective of the rate of bleeding.

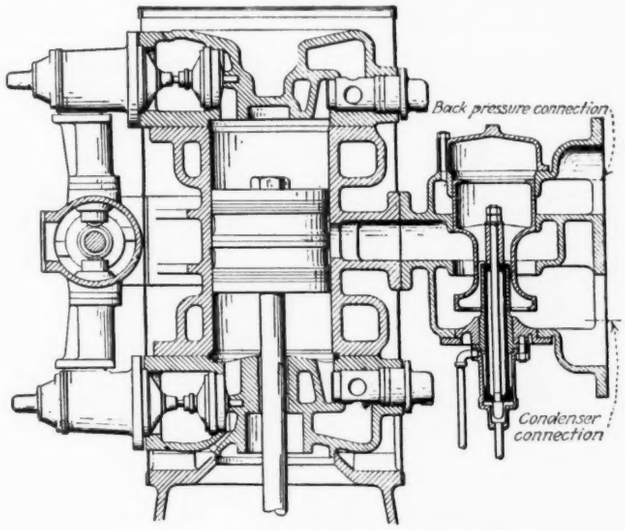


Fig. 5—A multi-cylinder uniflow with a bleeding arrangement

Occasionally, operating conditions demand heating steam at two or more distinct pressures. While it is feasible to bleed all the heating steam at the highest pressure and use reducing valves to obtain the lower pressures, still it would be more economical to bleed steam directly, at the desired pressures. A possible solution consists in employing stages for large pressure increments and handling smaller differences in one cylinder.

PROCESS STEAM PLANT
Uses Highest Type Equipment

By Theodore Maynz
Consulting Engineer,
Cleveland, Ohio

THE Cleveland plant of the Canfield Oil Company is in the city next to a railroad siding, which allows the spotting of two-hopper coal cars. Coal is unloaded into a 30-cu.ft. Beaumont full-automatic skip hoist which elevates it to the top of the hollow-tile silo. This silo is 18 ft. inside diameter, 56 ft. high above the rails. The upper compartment, or live storage, holds about 35 tons, which, when filled, overflows the coal into the lower part. This lower part has an actual available capacity of 250 tons. A chute with a hand-operated gate reclaims the coal from the lower part of the silo directly into the track hopper. With the coal flowing into the track hopper, the Beaumont "Simplex" unloader feeds the bucket of the skip hoist in exactly the same manner as when dumping directly from the cars.

The Cutler-Hammer automatic control operates the motor-driven winding machine, so that the coal is elevated, dumped into the silo, and after the bucket has hesitated long enough to empty itself, it is lowered into the pit, where the simplex unloader again fills the bucket. The speed of travel is fixed, but the time for dumping and loading can be varied by adjustment of the dashpot operating the control solenoids. From the upper part of the silo the coal flows through a chute into the boiler room. A clamshell gate operated by a lever from the floor fills the 1,500-lb. capacity chain-operated traveling weigh larry, from which the coal is dumped into the stoker hoppers. Coal is weighed by the operator and recorded by punching a printed card.

The ashes are dumped into a brick-lined, copper-steel ash hopper, made by the Beaumont Manufacturing Company having two 24x36-in. pivoted, self-draining gates. The capacity is about 130 cu.ft. An ash wagon, drawn by a Fordson tractor, enters through a door in the east wall and is driven directly under the hopper. After filling, it passes out through a door in the south wall at the west end. Ashes are quenched by Beaumont quenchers in the hoppers, operated from the firing floor.

The stokers are Westinghouse multiple-retort type, four retorts wide and 21 tuyeres long, equipped with double dump plates. The projected width is 7 ft. 3 in. and the length between walls is 10 ft. 1 in. Each stoker has a two-speed gear box and a built-in steam turbine driving the gears. Both dump plates are connected to the forced-draft air duct and dampered. A water spray having nine sprays of $\frac{1}{4}$-in. pipe projects from the bridge wall into the furnace at a height of about three feet above the dump plate, and another spray is placed in the windbox, discharging at the lower end of each row of tuyeres. These sprays were put in after the plant was operating, and were required to prevent the formation and adherence of troublesome clinker when burning Ohio coal under high ratings. Without these sprays the clinker would bridge over the dump plates, so that it was almost impossible to clean fires.

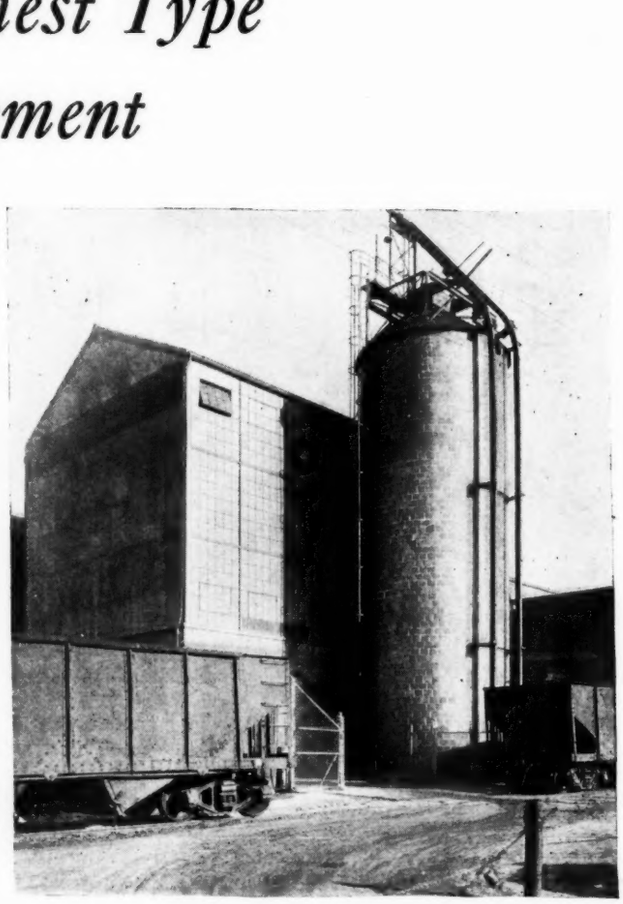


Fig. 1—New boiler house and coal-handling plant of Canfield Oil Company
Note fully glazed side of building and solid plaster end.

The boilers were made by the D. Connelly Boiler Company and are of the inclined vertical water-tube type, having 4,120 sq.ft. of heating surface each, built for 160 lb. pressure, A.S.M.E. They are suspended from steel columns which start from the basement floor. The mud-drum center line is 10 ft. 6 in. above the firing floor, and the steam drum is about 30 ft. above the firing floor. The boiler width is 7 ft. 6 in. between the inside faces of the side walls. The walls are 18 in. thick, so that the boiler is 10 ft. 6 in. wide. There is a clear

aisle of six feet between the two boilers. The total outside length from front to rear wall is 23 ft. The rear wall is undercut under the mud drum and has a clear height of 6 ft. 9 in. to the bottom of the beams.

The Foster convection superheater of 450 sq.ft. surface is between the first and the middle bank of tubes and has fifteen elements of the Foster cast-iron "doughnut" construction.

The original baffling was of the four-pass type, but the draft loss was too large. Tests showed that the loss was inherent in the boiler, so that a standard three-pass baffle had to be installed.

The brickwork is solid firebrick, 18 in. thick, consisting of 9 in. of "Farber No. 1" (Missouri clay) brick, all headers, tied in with 13½-in. headers every fifth course. This is in the furnace back to behind the first bank of tubes, the second pass being constructed of 4½ in. of "Farber" brick, and the last pass of second-quality (Ohio clay) brick. The upper part of the side walls are supported by steelwork, tied in by a section of Detrick suspended side wall. The front wall supported by the stoker is all of "Farber" brick, of the slip-wall type, tied in by bonding tile attached to the upper front wall steel. The upper front wall is built the same as the side walls, using 13½-in. header brick, supported on steel beams.

There is no usual steel front on the boilers. All the brickwork is supported at the floor line by steel beams attached to the boiler columns, which also support the stoker foundation beams. The combustion chamber has a 12-in. diameter soot chute with slide gate, to empty the soot into the ash hoppers. The water column is a Reliance, equipped with high and low water alarms and illuminated by two National gage-glass spotlights. The saturated steam nozzle is 6-in. Two 4-in. Consolidated safety valves are used on each boiler, with discharges extending through the roof. Each boiler has six rotating and one stationary Vulcan soot blowers of the valve-operating head type. Superheated steam is used for tube blowing. The main damper is mounted on roller bearings.

A concrete platform is built on the horizontal boiler-drum supporting beams, at an elevation of 41 ft. above the grade level. The Prat-Daniel stream-line stacks are on this platform, connected to the boiler outlet by a short flue discharging directly into the base of the stack. The base opening is about 5 ft. square. The fan runners, being of the double-inlet type, are mounted on ball bearings which are air-cooled and shielded from the heat of the gases. The stacks are 25 ft. high from base to top, and vary in area from a minimum of 2½ ft. square at the throat to 5 ft. diameter at the top. They are capable of handling 30,000 cu.ft. per min. of 675-deg. F. gases at 2.2 in. draft. The speed is 890 r.p.m. and requires 23.5 hp. The DeLaval turbines are direct connected without any reduction gear and are equipped with a constant speed and an emergency trip governor. No water cooling is used on either the fan or turbine bearings. The two boiler flues are cross-connected with a bypass damper.

EQUIPMENT used for generating process steam only, in the best type of modern plant, is described in this article. The engineering considerations upon which the choice of this equipment was based were discussed in POWER, May 22, 1928.

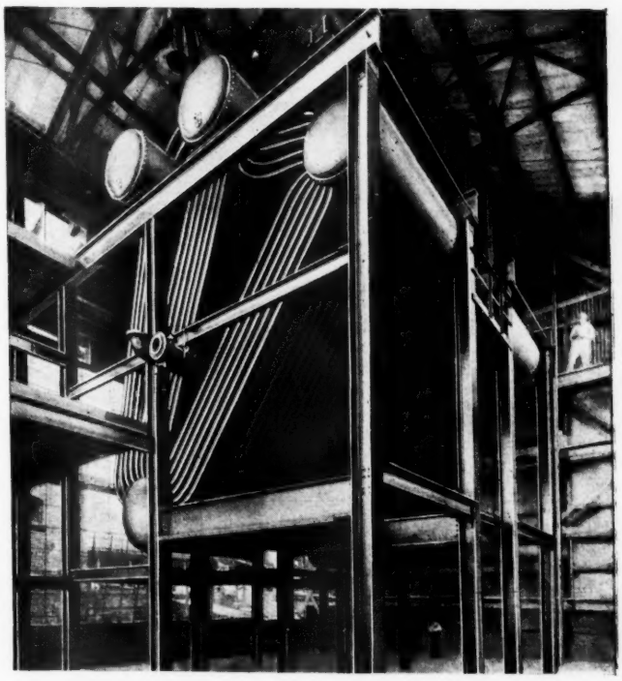


Fig. 2—Boilers during erection
Note simplicity of building construction as evidenced from interior view.

The forced-draft blowers are Coppus turbo-blowers, located in the basement, have each a capacity of 15,000 cu.ft. per min. at 5½ in. static pressure. They blow directly into the large plenum chamber under each stoker, and are cross-connected by a dampered 30-in. steel air duct, so that either fan can be used in an emergency. Each connection from the fan is equipped with a damper connected to the balanced draft regulator, which can be closed from the boiler-room floor if desired.

The exhaust from the auxiliaries goes through an 8-in. atmospheric relief valve, set at one-half pound back pressure, and a gate valve to a 2,000-hp. Cochrane deaërating heater with vent condenser. This heater is set on a platform 14 ft. above the firing floor. A 3-in. line feeds the water through a float-operated control valve, while the overflow is taken care of by a 3-in. water seal 10 ft. long, allowing a back pressure of 4½ lb. to be maintained if desired. The two boiler-feed pumps are set beneath the heater on the firing floor, fed by a 6-in. suction line. This is reduced to 4 in. where the line divides to the two pumps. There is a positive suction head of 16 ft. on the pumps.

The one boiler-feed pump is a turbine-driven DeLaval 2½-in. two-stage pump having a capacity of 120 g.p.m. at 415 ft. head. The turbine is equipped with an excess pressure and an emergency overspeed governor, but no constant-speed governor. The other pump, an emergency unit, is a Worthington 10x6x10-in. duplex piston pump, controlled by a 1½-in. Fisher excess pressure governor.

The control consists of a Hagan master regulator oper-

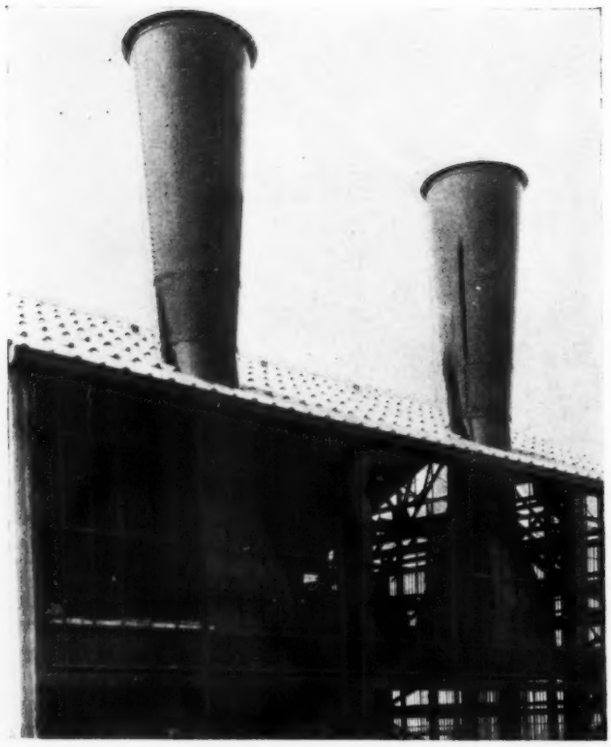


Fig. 3—Streamline or "Venturi" stacks lowered the construction cost of this plant with no sacrifice of efficiency or increase in operating cost

ating the Hagan roto valves on the induced-draft fan turbines by lineshaft and levers, and the roto valves on the forced-draft blowers by a cable and levers. The furnace draft is maintained at about 0.5 in. by a Hagan furnace machine on each boiler connected by a cable to the dampers in the air-duct connection between the blower and the stoker plenum chamber. The stoker speed is controlled by hand by the boiler operator.

The feed water is conditioned by the Hagan-Hall system of soda ash and concentration determinations. Soda ash is pumped by a small simplex pump to the deconcentrators, placed behind the boilers under the undercut combustion chamber. The boiler water is circulated from the collector in the middle drum through the deconcentrators back into the feed-water distributing pan in the rear drum.

Blowdowns are so scheduled as to limit the concentration to about 1,500 p.p.m., and the deconcentrators are back-washed twice in 24 hours. Determinations for concentrations and soda ash requirements are made once a day and maintained fairly closely. Any tendency for the boilers to foam or prime is taken care of by a Hagan separator in the steam drum, the water collected in Williams traps discharging into the blowoff line. By maintaining the boiler-water concentration below 2,000 p.p.m., there seems to be no tendency toward the delivery of wet steam.

Each boiler has a meter board in front, which has a Bailey boiler meter, a three-pen draft indicator, and a stoker speed indicator mounted on it. There is also an integrating Bailey-General Electric feed-water electric flow meter on the feed discharge line, a Foxboro recording thermometer on the feed-water pump suction, a Tycos indicating thermometer on the feed-water heater a Foxboro recording pressure gage and a thermometer on the main steam header and a Republic recording and integrating flow meter on the 8-in. steam line to the refinery.

The piping is as simple as could be designed, yet sufficiently flexible for a continuously operating steam plant. Steam is taken from the superheated outlet through a 6-in. Edwards non-return and a Lunkenheimer gate valve through 6-in. standard steel-pipe long-radius bends welded directly to the 8-in. straight header hung along the south wall of the boiler house. A Van Stoned flange is inserted in the boiler lead for the Bailey meter steam-flow orifice. This is the only joint between stop valve and the 8-in. main header valve leading to the refinery line.

From the main header, a 4-in. line runs directly to the induced-draft stack turbines, is reduced to 3-in. after feading these machines, drops down the west side of the building to feed the two 2-in. valves for the boiler-feed pumps, drops down into the basement to feed the forced-draft blowers with $1\frac{1}{2}$-in. connections, the stoker turbines with $\frac{3}{4}$-in. and the stoker steam dumps with $\frac{1}{2}$-in. connections. This line then continues and is connected into the main 8-in. header, making a complete loop. Sectionalizing valves are inserted between the various auxiliaries so that they can be fed from either end. The exhaust line is divided into two parts. The two 6-in. exhausts from the stack turbines are welded into an 8-in. header which drops down into an 8-in. lateral tee at the heater. A 5-in. exhaust header in the basement takes the exhaust from the forced-draft blower and stoker turbines and enters an 8-in. line which connects with the 8-in. lateral from the other exhaust. Another 5-in. exhaust line from the boiler-feed pumps is welded into the 8-in. line below this lateral.

The only fittings that are used in these exhaust lines are two 4-in. tees joining the forced-draft blower and the stoker drive exhausts, an 8-in. long-radius ell, an 8-in. lateral, and an 8-in. tee for the atmospheric relief valve. In addition, each stack turbine has an 8x6-in. reducing ell between the turbine flange and the gate valve; and the boiler-feed pumps also have ells between their nozzles and cutoff valves. The basement line is dripped by a 5-ft. long water seal. The upper 8-in. exhaust is not dripped.

The entire building inside, piping, steelwork, etc., was sprayed with aluminum paint. The machines, turbines, pumps, etc., and the brickwork of the walls up to a height of $4\frac{1}{2}$ ft. are painted black. A cost list is appended.

POWER-PLANT COSTS	Total	Per Rated Hp.	Per Maximum Hp.
Boilers, superheaters, soot blowers and brickwork	$28,285	$34.40	$14.15
Stokers and forced draft blowers	10,412	12.60	5.20
Stacks and drives	4,290	5.20	2.15
Ash hoppers, erected and lined	2,319	2.80	1.15
Air ducts and flues	1,300	1.60	.65
Coal handling, including foundations	12,970	15.80	6.50
Pumps and regulators	1,813	2.20	.90
Heater	1,364	1.65	.70
Feed-water treatment without piping	2,573	3.10	1.30
Combustion control	1,532	1.85	.75
Instruments and meters	2,416	2.90	1.20
Piping	10,390	12.60	5.20
Building	18,252	22.20	9.15
Machine foundations, gratings, etc	2,073	2.50	1.00
Miscellaneous labor, engineering, etc	6,927	8.40	3.50
Total	$106,916	$129.80	$53.45
8-in. steam line to refinery, including conduit	$4,225		

Use of PUMPS *in Eleven Services*

Shown by Survey

PUMPS as a whole comprise a major item of power-plant equipment. This is particularly true when the term power plant is taken in its true meaning to signify equipment for service to production without reference to its physical location in the plant.

To illustrate the point and to draw a comparison between the two chief types of pumps, *Power* has secured an inventory count covering eleven of the many pumping services in 600 industrial power plants.

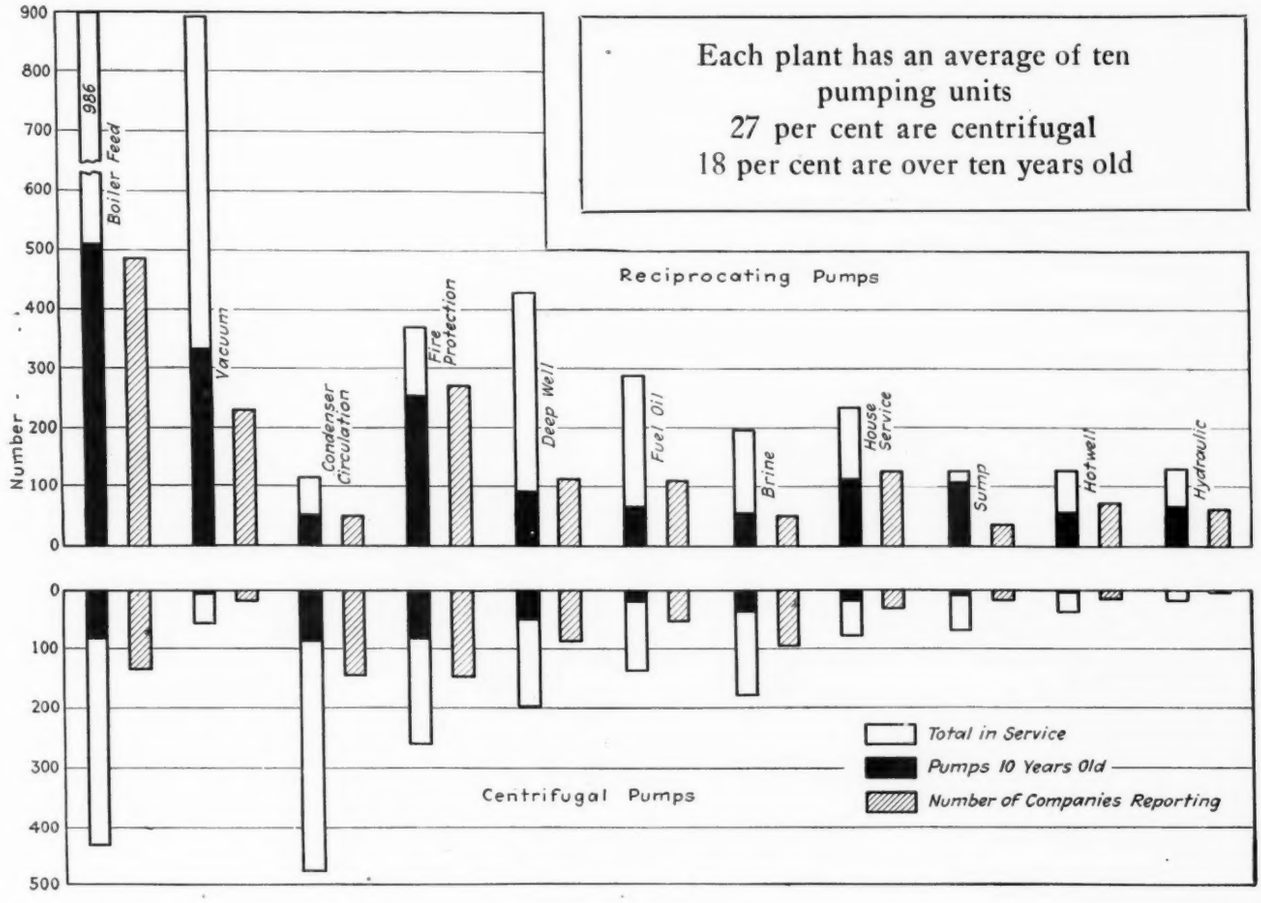
The services are named and the counts shown under the accompanying charts. Altogether, 5,910 units were found to be in service in the 600 plants, an average of approximately ten pumps per plant. The plants themselves represent a total of approximately 12,237,250 sq.ft. of boiler heating service, or an average, taking boilers as the base, of 2,000 sq.ft. per pump.

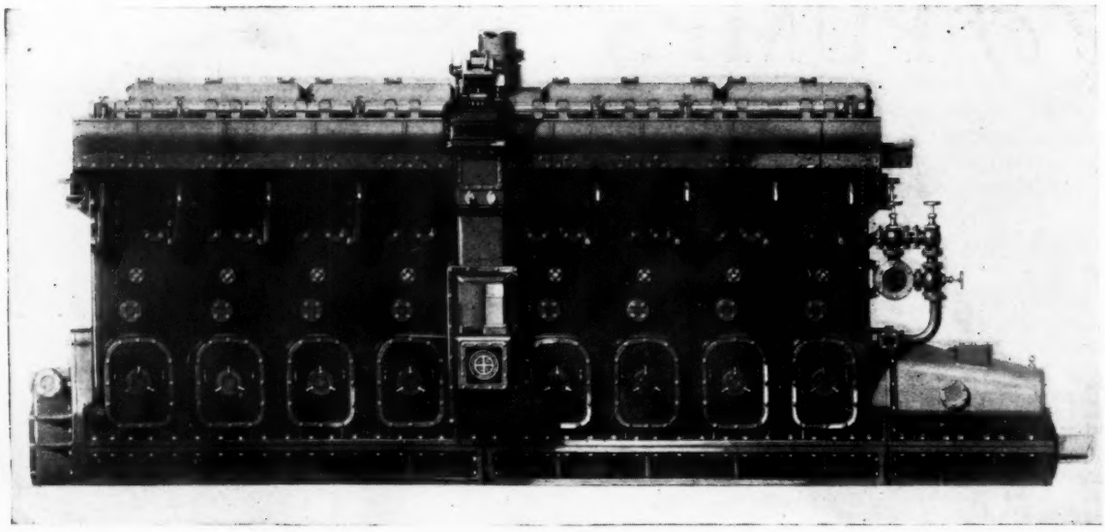
Questions to bring out the balance between centrifugal and reciprocating pumps were included in the study—as well as questions to show the percentage of old equipment. These points are all recorded on the chart, as well as the number of companies reporting the use of pumps in each service.

By way of further explanation of the chart it is seen that 1,418 boiler feed pumps were reported by the 600 companies. Of these, 432, or about 30 per cent, are centrifugal, while 986, or 70 per cent, are of the reciprocating design. Of the 432 centrifugal pumps as reported by 138 of the 600 companies, 81 are shown to have been purchased prior to 1917.

Of the 986 reciprocating boiler feed pumps as reported by 486 of the 600 companies, 511 have seen ten years or more of service. Comparing the two, it would seem that centrifugal pumps are of more recent installations by 33 per cent.

The same comparisons are drawn for each of the eleven groupings shown. The data can be used to indicate trends in design as well as to point out present conditions.





A 1,500 hp. Bessemer Diesel running at 325 r.p.m.

NEW DESIGNS OF DIESEL ENGINES

Use Higher Speeds

DIESEL engine designers are concentrating on two general lines of developments—higher speeds and larger engines.

The Diesel has in the past been a slow-speed engine; seldom was 200 r.p.m. exceeded save on small units, which ran at speeds up to 300 r.p.m. Even for small powers these speeds required a heavy engine and barred the application of the Diesel engine to mobile equipment such as shovels, locomotives, light motor boats and trucks.

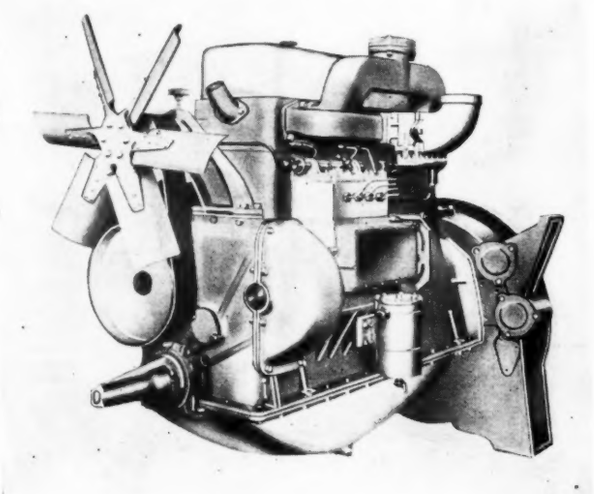
In addition the large dimensions of the slow-speed engines entailed a high manufacturing cost.

These facts prompted designers to increase the speeds to 500 to 600 and finally to 800 r.p.m. The result has been a wider field of application and the general acceptance of the Diesel for all types of power requirements. At present several manufacturers are building Diesels operating at from 500 to 900 r.p.m. Many are being installed on industrial locomotives and contractors' machinery.

The day of the Diesel engine operating at 2,000 r.p.m. and suitable for use on light automotive vehicles is within sight. Even at present engines are being built to operate at 1,000 to 1,200 r.p.m. Such engines have been in use in Germany for about three years, but only during the past year has an American firm actually engaged in the manufacture of such an engine on a production basis. One of the illustrations shows the Buda engine, which is built under the German MAN license by the Buda Company, Harvey, Ill. While the engine is not as light as an automotive gasoline engine, its weight of 1,100 lb. at 50 hp. output brings it within reasonable use for truck service.

In the past engines for medium and heavy duty have had low piston speeds. There is a marked trend toward higher speeds in the heavy-duty engines. Among these engines are the two 1,500-hp. Bessemer Diesels for yacht service, designed to operate at speeds up to 322 r.p.m., making the piston speed as high as 1,200 ft. per min.

The truck Diesel produced by the Buda Company



In larger engines, those of 3,000 hp., the tendency to higher speeds is noticeable. Engines of 42-in. stroke turning 125 r.p.m., which gives a piston speed of 875 ft. per min., have been built by several manufacturers, while 200 r.p.m. for 32-in. stroke engines is now usual.

This increase of speed should assist in a lowering of Diesel plant costs. The engine undoubtedly requires more careful manufacture than a slower-speed machine, but eventually will cost less.

How the LARGE DIESEL *is Designed and Applied*

By Edgar J. Kates

Consulting Engineer, New York City

ONE of the outstanding trends in the oil-engine field during the last two years has been that toward the greater use of large engines. At the present stage of development the term "large engines" may be taken to refer to units larger than 1,000 hp. Not only are numerous engines of 1,000 to 2,000 hp. being installed, but the upper limit of size is steadily being lifted, and commercial use is being made of engines in larger and larger sizes. The biggest engine installed in the United States at the present time has a rated capacity of 3,750 brake-horsepower.

In the gradual development of the large Diesel a number of problems have been successfully solved. In some cases credit is due to the designers of foreign companies whose licenses are held by American manufacturers; in others, the solution is entirely "home-brewed." Typical of the latter is a cylinder head design of hemispherical shape, made of a single steel forging. In general, however, cylinder head designs are similar to those used in smaller engines, and the heat stresses are kept within satisfactory limits by the same practices developed by experience with smaller units. This is true also of piston head designs.

In the case of double-acting engines the additional problem of the piston rod packing was solved by following the lead of the large gas engine. In fact, this much feared factor in the design of double-acting Diesels went through with remarkable smoothness and caused many a designer to smile over his anticipated worries. Naturally, some experimental work had to be done in connection with the arrangement of the sprays in the bottom cylinder.

No Dangerous Critical Speeds

Critical speed vibrations have not been bothersome in large Diesels, because they are slower running than smaller engines and also because in the last few years definite methods for predicting criticals have been established, thus making it easy to forestall trouble.

The greatest incentive for the development of large Diesels has come from motorships. The oil engine had its inception on the other side of the water, and our European friends have, from the start, evinced a greater appreciation of the merits of oil-engine power. The economy of the motorship was quickly recognized, and at present more than half the shipbuilding of the world is being devoted to motorships. The total tonnage registered in 1927 with Lloyd's was 4,270,824, showing how rapidly the motorship fleet is growing.

The competition of European motorships has become a serious matter for American ship-owners and has compelled this country to take stock of itself with respect to the manufacture of Diesel engines of suitable size for modern freighters. The United States Shipping Board was thus led to definite action in the interests of the American people. It placed orders with American manufacturers for twelve Diesel engines of about 3,000 b.hp. each for the purpose of converting into motorships a corresponding number of steamers whose previous operation had shown a disheartening loss. The conversion program had a twofold object. It not only served to acquaint the American shipping industry with all the facts about the modern motorship, but it also encouraged a number of American engine manufacturers to undertake the construction of Diesel engines in large sizes for which there had heretofore been little demand.

Large Engines Now Building

The program was successfully carried out, and the Shipping Board has recently placed orders for eight more Diesel engines of still larger size; that is, about 4,000 b.hp. each. American builders produced 3,000-hp. engines with so little difficulty that it appears certain that, upon demand, they can emulate their European brethren who have already built Diesels as large as 15,000 b.hp.

Mainly as a result of this constructive action on the part of the Shipping Board, there are now six American concerns that have actually built successful Diesel engines in sizes of 3,000 b.hp. or more. Though most of the designs were originally made for marine use, they can easily be conformed to stationary conditions by merely changing the shape of the bedplate and omitting the reversing mechanism. The stringent service of marine propulsion, which demands unfailing reliability combined with the utmost power production, leaves no doubt as to the suitability of these engines for stationary use.

Confidence in the ability of American manufacturers to construct satisfactory Diesel engines in large sizes has opened up a number of new fields of application. With only small engines under consideration, such applications were not feasible because of the multiplicity of units that would have been required. Now, however, with the success of the large Diesel well demonstrated, these applications are looked upon from a new viewpoint.

Oil engines have long been used in industrial power plants, particularly where the heat requirements are less than the need for power, or where the heat and power demands do not occur at the same time. In such plants

the heat is supplied by low-pressure steam boilers to the extent needed, and the power is furnished by oil engines. In many cases this combination has shown lower costs than all alternatives.

Larger industrial establishments, however, have often found themselves unable to adopt this combination, and have accordingly used condensing steam equipment or purchased electricity to supply the power required in excess of that producible from the steam needed for heating.

The advent of the large Diesel engine has changed this situation, and there is a distinct trend toward combined steam and Diesel plants. Many paper mills can now profitably utilize such combination plants. Steam is needed for drying the paper on the rolls of the huge Fourdrinier paper-making machines, and this quantity of steam suffices to produce the power to run the machine itself. But the paper mill, as a whole, needs twice as much power as can be obtained from the process steam, and the large Diesel engine offers an economical method of driving the beaters, jordans, etc.

Cotton spinning mills are another example of an industry that requires much more power than heat. The particular advantage of the Diesel engine compared with purchased power, is that the mill need not be placed near a transmission line close to a source of cheap electric power, but on the contrary, may be located solely with respect to the factors of labor supply and transportation. The oil engine will provide cheap power whatever the location. In this respect it differs from steam power equipment because it consumes but little fuel and that is cheaply transported, and also because there is no need of huge quantities of water for condensing purposes.

Mining operations demand abundant power conditions favorable to the use of large Diesel engines. Quite a number of large mine power plants have been equipped with Diesel engines, one of the most recent being the 6,750-hp. generating station constructed last year by a zinc-mining company in Oklahoma, powered by three Nordberg Diesels.

The great cost of building long-distance, large-capacity, high-tension power lines and the many difficulties in maintaining reliable service, have caused some public-utility operators to realize that superpower projects are not as wholly desirable as they first appeared to be. The idea of superpower is derived from the fact that small steam power plants are thermally inefficient, and maximum economy can be had only in stations of the largest size. Though such stations produce exceedingly cheap power, the cost and difficulty of transmitting it for long distances have proved most burdensome.

Modern large Diesel engines are now used to advantage by electric public utilities operating widespread systems. Diesel generating stations are placed at stragetic points in the territory, each efficiently serving its own community through short transmission lines. Sometimes these lines are joined into a network, giving all the benefits of interconnection, such as emergency reserve and improved load factor. In all cases, the short, low-capacity transmission lines are inexpensive and the electrical losses are small. Furthermore, a more uniform

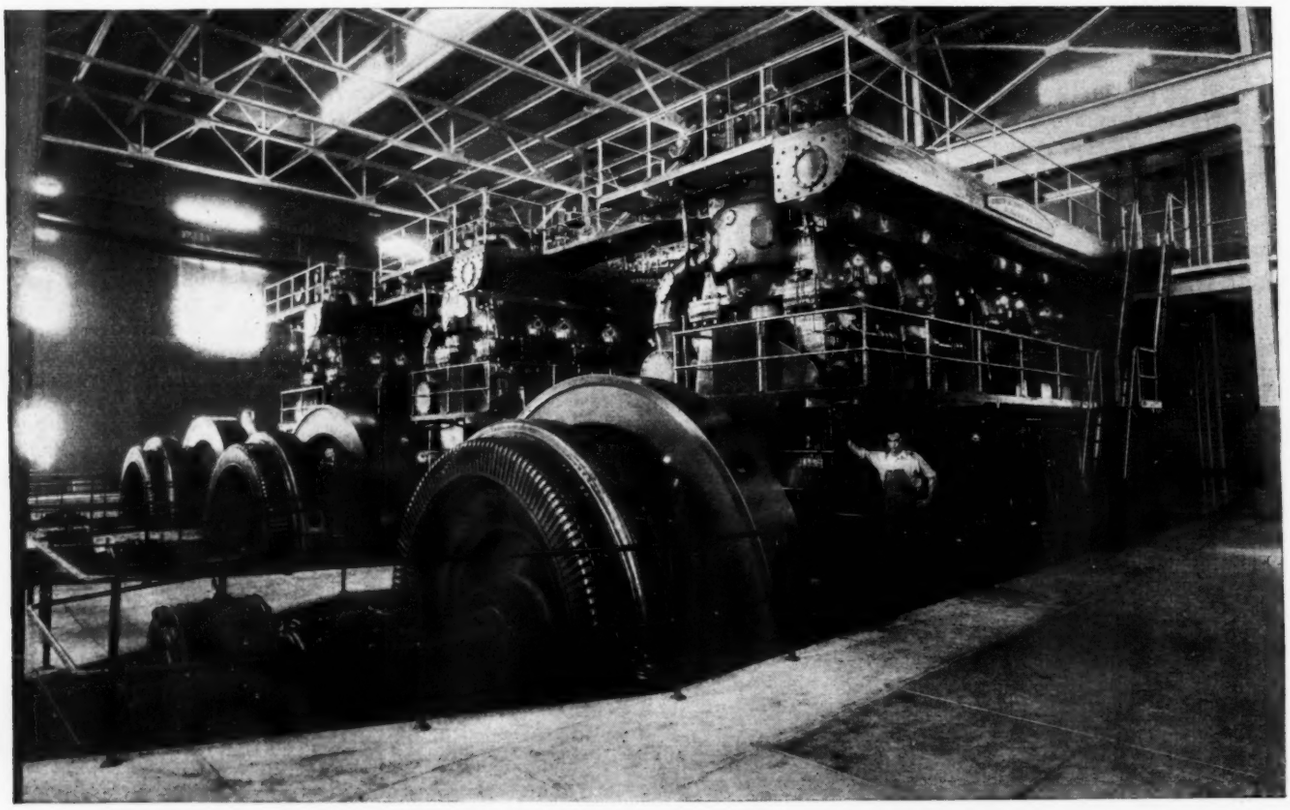


Fig. 1—Interior of Commerce Mining and Royalty Plant containing the 2,250-hp. Nordberg Diesels

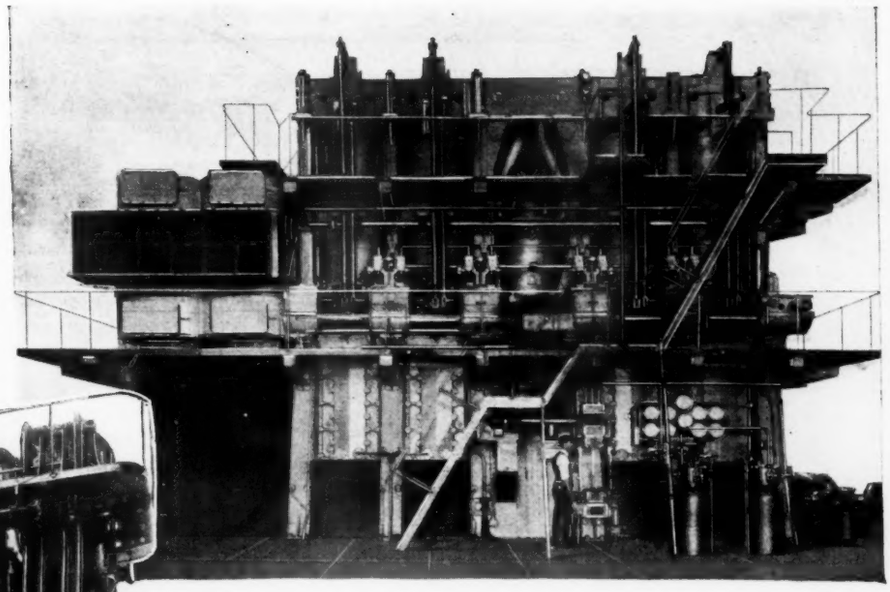


Fig. 2 — (Right) — A 3,000-hp. Hooven, Owens, Rentschler double-acting two-stroke -cycle Diesel

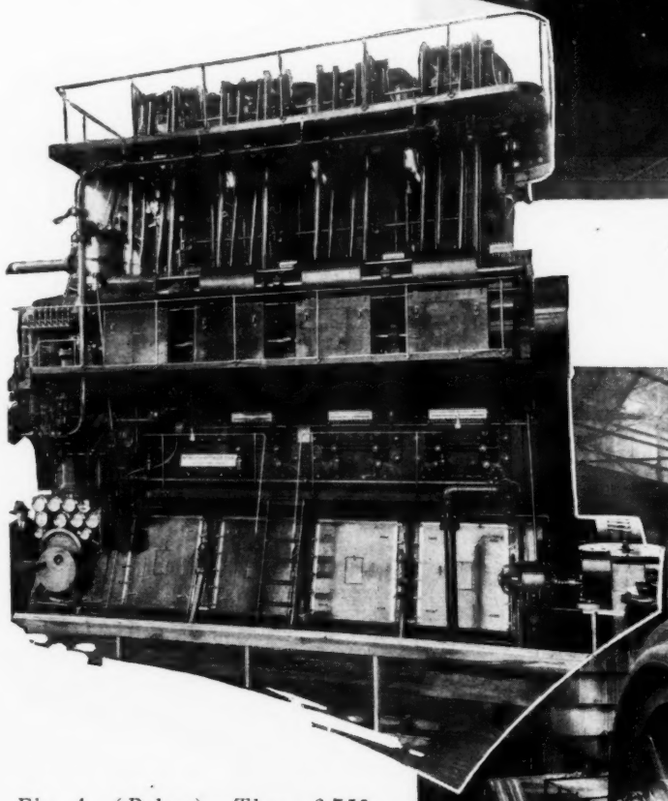


Fig. 3—(Left)—3,000-hp. McIntosh & Seymour four-stroke-cycle double-acting engine

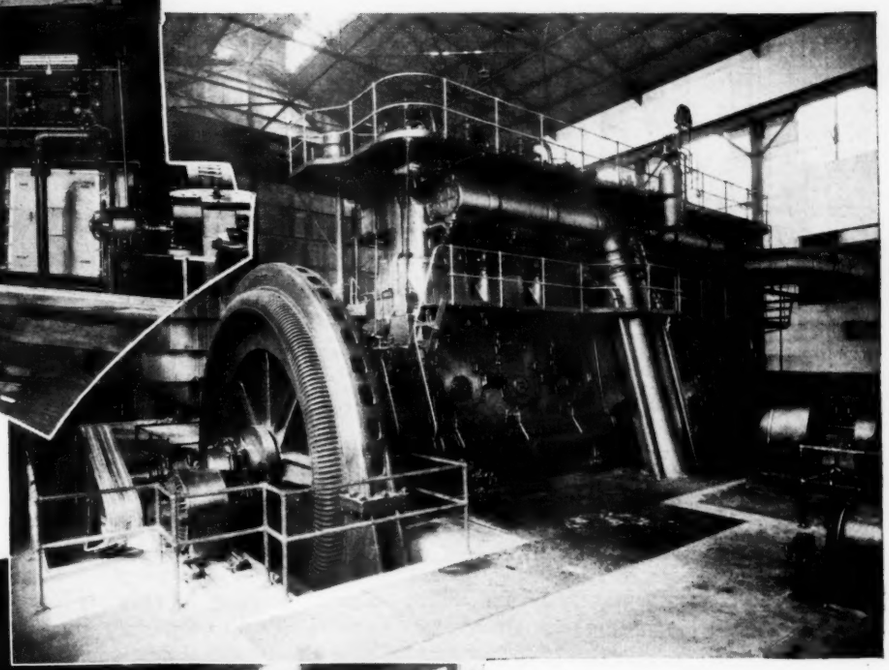


Fig. 4—(Below)—Three 3,750-hp. Nordberg Diesels in Panama Canal stand-by plant

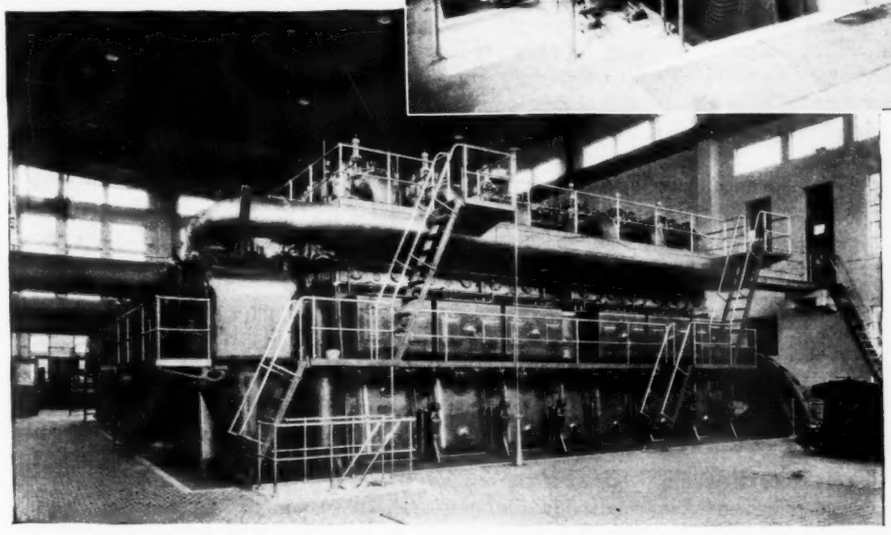


Fig. 5—(Above)—A 3,750-hp. Busch-Sulzer Diesel in Tucson, Ariz., plant

voltage is maintained, and better service in general given to the consumers.

A two-stroke-cycle, single-acting Busch-Sulzer Diesel just installed in a Tucson, Ariz., central station is shown in Fig. 5. It is rated 3,750 b.hp. at 124 r.p.m. and has carried peak loads of 3,000 kw. in service without difficulty. The cylinders are 30-in. diameter by 42-in. stroke.

Another service that the large oil engine offers the electric public utility is that of supplying the peak loads

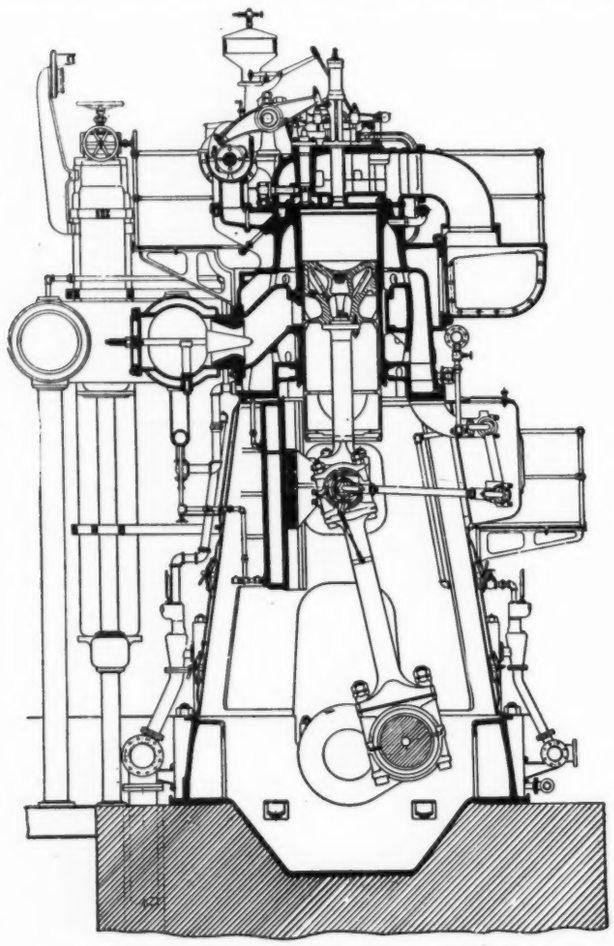


Fig. 6—Cross-section of Nordberg 3,750-hp. Diesel

in great steam central stations. The economics of this application depend mainly on the fact that an idle Diesel engine consumes no fuel and requires no attendance, while boilers banked for extended periods burn large quantities of coal and demand fireroom attention. Several Diesel installations of this kind have been made abroad, where the conditions would seem to be less favorable than here, because there coal costs less and oil costs more than in this country. These engines range in size from a 1,200-kw. unit in the Charing Cross steam station in London to the huge 10,000-kw. unit in the municipal power plant at Hamburg. Two 7,500-kw. outfits are now being placed in one of the Berlin central stations.

The question whether peak-load applications of Diesel engines in large public utility plants would be economical in the United States depends upon many factors differing in each station. The savings that seem to be possible would justify making detailed studies of certain cases. The item of first cost is serious, and when costs of large Diesels come down with greater production, their economic importance in this field will steadily grow.

Hydro-electric systems require reserve and stand-by power to provide against water shortage and against transmission line outages. Because of the huge amounts of energy involved in most such systems, this stand-by power has been almost invariably furnished, in the past, by large steam stations situated near the load centers. However, engineers are now aware of certain distinct advantages that the modern large Diesel offers in this service.

An outstanding example of this type of Diesel application is the 7,500-kw. stand-by plant put into operation last year in the Panama Canal Zone. It consists of three similar units of the Nordberg six-cylinder, two-stroke-cycle, single-acting type, the cylinder dimensions being 29-in. diameter by 44-in. stroke, operating at 125 r.p.m. The plant is exceptionally attractive in appearance, as will be noted from view in Fig. 4. A cross-section through a power cylinder is shown in Fig. 6. Incidentally, this is at present the largest Diesel engine plant on the American Continent, having a peak load capacity of 12,375 horsepower.

LARGE DIESEL ENGINES

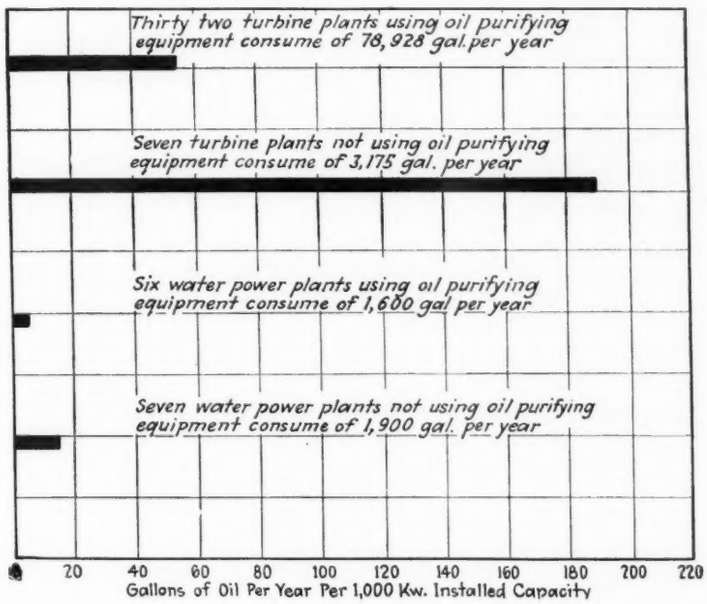
Manufacturer	Type of Engine	No. of Cylinders	Cylinder Dia., In.	Cylinder Stroke, In.	Rated B.hp.	Rated Speed, R.p.m.	Completed Weight, Lb.
Worthington	Two-stroke, double-acting....	4	28	40	2,900	95	740,443
McIntosh & Seymour.	Four-stroke single-acting....	6	32	60	2,700	95	966,270
McIntosh & Seymour.	Four-stroke, double-acting....	4	32	52	2,700	95	765,000
Busch-Sulzer....	Two-stroke, single-acting....	6	30	52	3,000	90	850,000
		6	30	42	3,750	124	.....
Hoovens, Owens, Rentschler	two-stroke, double-acting....	4	27½	47.5	3,300	95	871,000
New London	two-stroke, double-acting....	4	27½	47.5	3,300	95	871,000
Nordberg...	Two-stroke, single-acting....	6	29	44	3,750	125	.....

Inasmuch as the large Diesel engine is still in process of development, it is important that purchasers should not unduly hamper the manufacturers by unnecessary specifications. For instance, to require the engine builder to make cylinder liners or piston rods of materials precisely defined as to chemical composition, may compel him to forego using materials that from his own experience he knows to be more suitable. So much attention is today being focused on all the large Diesel engines put into service that there is danger of any manufacturer risking his reputation by using anything but the best.

As to the trend of the large Diesel, there seems little doubt that maximum sizes will be steadily increased. The records of several manufacturers show each year a higher average size of engine supplied for stationary use. Because of the rapidly increasing weight as cylinder dimensions grow bigger, there is a logical tendency, in the larger stationary engines, to hold down the cylinder diameter and stroke and to increase the speed.

How Much
OIL
Do You Use?

Yearly Consumption of Oil


Thirty two turbine plants using oil purifying equipment consume of 78,928 gal. per year
Seven turbine plants not using oil purifying equipment consume of 3,175 gal. per year
Six water power plants using oil purifying equipment consume of 1,600 gal per year
Seven water power plants not using oil purifying equipment consume of 1,900 gal. per year
0
20
40
60
80
100
120
140
160
180
200
220
Gallons of Oil Per Year Per 1,000 Kw. Installed Capacity

Everyone knew that purifiers made a difference in oil consumption; but what a difference it is!

THE problem of proper lubrication is one in which every operating man is interested and one that many have spent much time in solving. Once the bearings that used to run hot are made to run cool, the plant man is often satisfied to leave well enough alone, even though he may be using many times the amount of oil necessary.

The results of a recent survey of central-station plants made by *Power* were analyzed to determine what factors influence the consumption of lubricants. Reports from 105 plants showed a total consumption of lubricating oil of 134,664 gal. per year, and 81 plants reported a consumption of 62,645 lb. of grease per year. These reports were from plants having a range in capacity of from over 200,000 kw. to small plants of less than 1,000 kw. The average lubricant consumption was found to be about 59 gal. of oil and 28.5 lb. of grease per year per 1,000 kw. of installed capacity.

It was found that the use of purification systems was one of the factors that influenced the amount of oil consumed, and its effect is shown in the chart. Thirty-two steam turbine plants equipped with an oil purification system reported an oil consumption of 54.2 gal., while seven steam-turbine plants not equipped with oil purifiers reported a consumption of 189 gal. per year per 1,000 kw.—a consumption of more than three times the oil used by plants using purifiers.

Similarly, of thirteen water-power plants reporting, six plants equipped with purifiers showed a consumption of 6.2 gal. of oil per year per 1,000 kw. of capacity, while seven plants showed a consumption of 14.7 gallons.

Many of the plants reporting contained both turbines and reciprocating engines. The consumption of lubricating oil in these plants equipped with oil purification systems was much higher than for turbine plants—about 133 gal. of oil per year per 1,000 kw. Assuming that this increase in oil was used by the reciprocating engines, a figure of 690 gal. per year per 1,000 kw. was found as the oil consumption for reciprocating engines.

Analysis of the grease used indicates that plants using chain-grate stokers require 13.7 lb. of grease per year per 1,000 kw., while plants equipped with underfeed stokers use 30.6 lb. of grease, or slightly more than double the amount used by plants using chain grates.

DEVELOPMENTS IN HEATING
Move Forward Rapidly

By D. D. KIMBALL
Consulting Engineer, New York City

AT NO time within the last thirty years have there been more varied, interesting and important developments in the heating field than within the last year and a half or slightly more. Among these developments are those which make for both reduced installation costs and reduced operating costs.

The basic element of a heating plant is the boiler. Very few new designs of heating boilers have been offered recently, but there is an increasing tendency toward the use of the firebox steel boiler of welded construction in small heating installations. In larger low-pressure heating work the use of the welded steel firebox boilers continues with increasing pace, additional manufacturers continually adopting this form of construction, with the capacities of welded heating boilers extending to the largest sizes of heating boilers made.

THE art of heating is not lagging in the march of progress. Boilers, fuel applications, radiation and manual and automatic control all show continued improvement.

Heating with gas is now making real strides, as a result of concentrated drives by the public service companies. Two problems remain to be solved to make gas the most popular and most generally used fuel for heating. First, to provide a durable gas furnace or heater which will consume the gas at something approaching the possible efficiency; and second, a disposition upon the part of the gas companies to sell gas for heating purposes at such a rate as will make economically possible its use as fuel.

Gas heating furnaces of a higher efficiency are being developed, and there is indication that the gas companies are striving to find some solution of the cost problem. Happily, there thus appears hope for a wide use of gas as fuel in the not distant future.

Next in importance in the heating system to the boiler and fuel is the radiation. The forms, or designs, of radiators have been undergoing marked changes. The former clumsy and space-consuming cast-iron radiators have already given way to the new near and condensed cast-iron radiators. New types of window radiators are now available. More recently, brass and copper radiators with extended fins or flues have been coming into use quite largely. Several forms and makes of these types of radiators are designed for enclosure in recesses or cabinets under windows or within the walls, being so narrow as to make such inclosing entirely possible within the usual wall construction. A minimum of space is required by these radiators, a maximum of efficiency is obtained, and the floor space is saved which was formerly occupied by the cast-iron radiators. With easier means of controlling the heat from this type of radiation, there is also found a more even heat distribution.

For industrial buildings the so-called ventilating or heating units are largely replacing the direct radiation or blower systems of heating.

New forms of radiator control valves, especially of the modulating or graduating type have recently been placed upon the market, designed for more efficient manual control of the degree of heat. But of greater interest and importance is the placing upon the market of an automatically operating valve which is designed to be applied to each radiator to maintain, without attention, a constant room temperature, regardless of the outside temperature, so long as heat is required. The use of such a direct control valve, which is applicable to the radiators of any two-pipe steam or vapor heating system, not only provides heat control, but with this it assures reduced fuel consumption.

Available also are forms of orifice and differential vacuum control, all designed to give greater satisfaction in heating and a lowered fuel consumption. It is more and more recognized that control is a major factor in economical heating.

The vacuum system continues to increase its percentage of the total heating installations, and vapor heating systems are largely used in small buildings and residences.

Increasing efforts are being put forth to modify the dryness of the atmosphere of modern heated apartments. Certain of the cabinet, or inclosed, radiators to which reference has been made, are designed with water pans to provide moisture to the air. Humidifying pans that may be placed on exposed radiators are available. An independent humidifier in which the water is evaporated by means of an electric element may be had. Another humidifier, in which water is vaporized by a little motor-driven fan, is also available.

Perhaps the newest and most revolutionary development in the heating field is that of a newly patented and installed combined heating and cooling plant which is now or shortly will be generally available. This consists of a gas-operated warm-air furnace of very high efficiency for winter use, combined with a small refrigerating machine having no moving parts for cooling in the summer. It includes a humidifier and an air filter. It includes, also, a motor-driven fan, hence thorough heating or cooling is assured regardless of wind direction or velocity. This equipment is intended for small buildings generally, or multiple units may be used in larger buildings.

Allied with the heating problem is the problem of ventilation. Upon this subject there is today being expended more time, effort and money than ever heretofore.

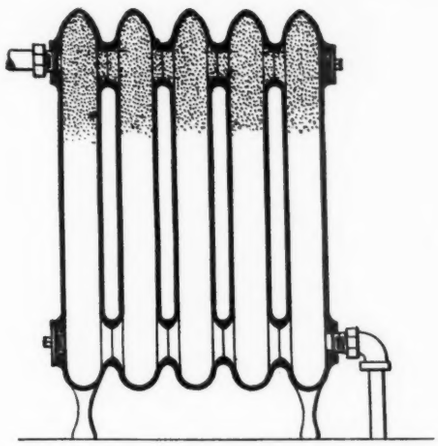


Fig. 1—Partly heated radiator

ORIFICE *and* ZONE *Systems*

Suit Heat Supply to Weather

By WEBSTER TALLMADGE
President, Webster Tallmadge & Company, Inc., New York City

THE last year has witnessed the adoption of several new types of radiating units. They are such as the industrial unit heaters for large factory rooms in which the air from the room is recirculated by a fan over heating elements built for high rates of heat emission, the invisible radiator consisting of a copper heating element built into a flue or chase in the wall, for offices, hotels and residences, and the tube-type direct cast-iron radiator. It is therefore no longer satisfactory to express radiator capacity in terms of square feet of radiator surface. The calculations must be more precise and in terms of actual heat transfer. There is also need of a larger unit than the British thermal unit. The kilotherm has been suggested by the power boiler user and has much to commend it.

The heat transfer from the radiators to the building must equal the heat loss from the building to the outside atmosphere in the most extreme weather. Operating under this full capacity condition, most buildings are greatly overheated in mild weather. Until the last few years little provision has been made to reduce the supply of heat in a scientific manner and large quantities of fuel are wasted annually by compelling the occupants to moderate the temperature of buildings by opening the windows and throwing away heat made from valuable fuel.

From observations of partly heated radiators such as shown in Fig. 1, it is seen that the performance of the heating element can be made suitable. The steam, owing to its bouyancy, flows to the top of the radiator. The condensate is further cooled by flowing downward over the lower surfaces at practically room temperature. The air being heavier than the steam, flows naturally to the bottom of the radiator and outward through the return piping to the bottom of the system, if permitted to do so freely, without inducement from a vacuum pump.

Steam piping until recently has been universally designed from tables giving a certain number of square feet of radiation for a certain pipe diameter. These were based on a pressure drop of one ounce for each one hundred feet. This resulted in the steam pipes being too large on short runs and too small on long runs. From this it will be understood that the frictional resistance of the pipe to near-by radiators is less than to those nearer the extreme end of the steam main. For this reason the radiators nearest the supply end fill with steam first. If the system is full of steam and the supply is reduced, the radiators at the extreme end of the line cool off first, as shown in Fig. 2, owing to the difficulty with which the steam reaches these radiators because of the greater resistance or pipe friction. It can therefore be understood that it has not been possible to reduce the steam supply systematically in mild weather to obtain the desired fuel economy. Overheating of buildings is, therefore, frequently experienced. Overheating is not only

wasteful of fuel, but induces debility in the occupants, with low vitality and poor production results. Overheated rooms are frequently thought of as poorly ventilated, although they may actually have an ample supply of oxygen.

During recent years improvements have been made in design for economy. The intermittent type of control, in which the full supply of steam is turned on for a few minutes and then completely turned off for a similar period, has done a great deal in the right direction for those having systems such as one-pipe on district street steam supply. District or street steam supply being very easily turned on, is therefore frequently wasted. Steam companies have for years studied means of keeping down this wastage, and the intermittent control has been helpful to them in this way.

An important development in heating system design for improved comfort and economy to the two-pipe system has been the orifice system of distribution, and zoning of the heating systems whereby the heat is put where needed and spread out to all radiators in proportion to the requirements, as shown in Fig. 3.

Orifice Systems Described

There are several types of the orifice system; namely, the low-pressure orifice system, the high-pressure-muffled orifice system and the compound orifice system.

The orifice system for the control of heat to radiators was used as early as 1877 by Birdsill Holly, the great-grandfather of district heating. The late Prof. S. Homer Woodbridge, of Massachusetts Institute of Technology, used a more elaborate system in a number of buildings, among them the Capitol group in Washington as early as 1904. Some elaborate work has been done by others. Birdsill Holly's work was surprisingly consistent, and he evidently realized the shape of the characteristic flow

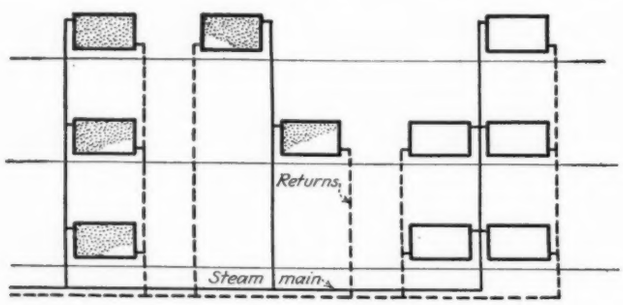


Fig. 2—Common two-pipe system showing how near-by radiators receive all the steam when the supply is reduced

curve, which gives greater proportional quantity at low pressures.

Low-pressure orifice systems have been in use for many years. The older systems operated on the principle of constant low pressure from a sensitive reducing valve on the supply, and the occupant varied the area of the orifice to heat more or less of the radiator by turning the handle of the radiator steam inlet valve as he chose from day to day. Traps were not used on the radiator outlets, as the steam was described as floating in the top of the so-called atmospheric radiators and reached the outlet or return elbow only when the steam valve was wide open at full hot, or maximum load. These systems did not use vacuum on the return and air valves were not necessary. The air expelled from the radiators when steam was turned on found its way through the return piping to simple air outlets at the bottom of the system.

In the compound-orifice system the flow to different portions of the system is balanced or compensated against the frictional resistance of the main piping and riser by primary, or divisional, orifices at each riser or branch.

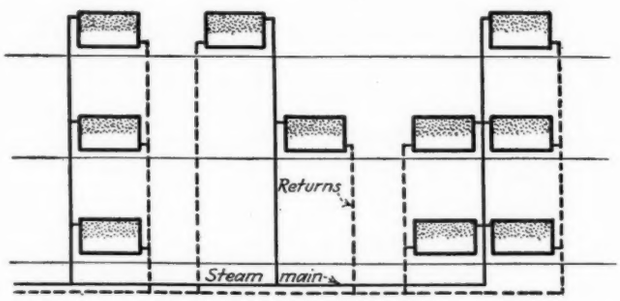


Fig. 3—Orifice system—each radiator receives a portion of the steam supply

Each radiator is provided with an orifice of such size as to compensate for the pressure drop due to the riser friction and radiator size. This system was a big step in the right direction. The pressure drop across the orifices was small and the performance not always stable.

Owing to the steep curve of the steam-flow characteristics at low pressures, it was not easy to regulate large low-pressure orifice systems at the source of supply and obtain the low rates of heating desired.

Regulation of Steam-Flow Noise

The noise of the steam flow through orifices increases with the pressure differential. It is therefore undesirable to exceed certain pressure limits with ordinary orifices. Good performance can, however, be obtained by proper choice of design, and satisfactory regulation will result with the ordinary orifice.

Radiator valves with muffled orifices are obtainable. They perform without appreciable noise and with excellent regulation on several pounds pressure drop. With this type of orifice valve the pipe friction becomes less important and good regulation at low rates of flow is easily accomplished.

With the present high degree of development, the orifice system of distribution is becoming more popular among engineers desirous of better economy and comfort.

A popular method is to divide the heating system into zones, or several small systems. Each zone is arranged to supply a different demand for heat, according to the type of occupant or exposure of the building. The sunny side of a building needs less heat than a shady side. The air leaking through walls of a windy side requires enough heat to warm it sufficiently for the comfort of the occupants. This air, after being warmed, flows through the building to the leeward side. In such a case there will be more heat needed on the windward side and less on the leeward side. Rooms with large amounts of power-consuming machinery receive heat from the frictional dissipation of the power. Each kilowatt-hour has a heat value of 3,412 B.t.u., which is more than is given off

by ten square feet of radiating surface. It is therefore frequently found under such conditions that the radiators need be used only for preheating and during inoperative periods, except possibly for a slight amount on extremely cold days.

Zoning of the orifice type of heating system has brought about the development of a system of electrical remote control whereby any number of zones or steam admission valves can be adjusted by the handles on a relatively small panelboard.[1] These panelboards may be equipped with sunny- and shady-side temperature indicators and wind velocity and direction gages. They are

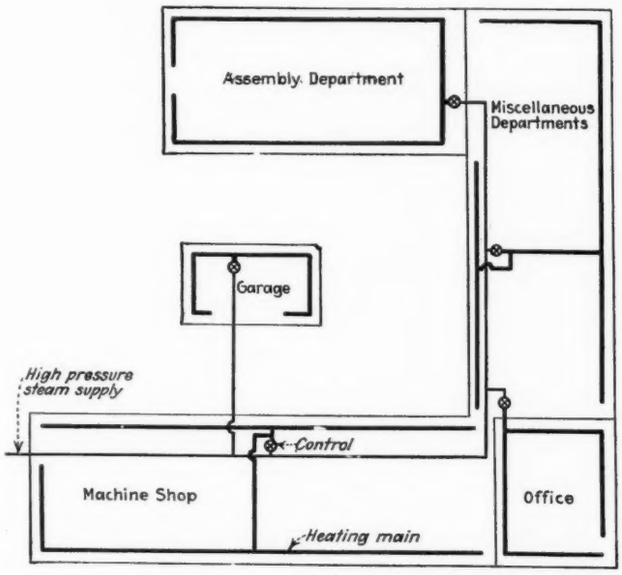


Fig. 4—Zoned heating system

so calibrated as to be readily adjusted for maximum economy and comfort. In some cases the temperature of various critical rooms is brought back to the panel in the control system.

The zone-controlled orifice system of steam distribution improves the economy, and in some cases the fuel consumption of existing buildings has been reduced 40 per cent. The first cost in new buildings is lower owing to smaller pipes because of the fact that the pressure drop between boiler and point of control can be several pounds. It is also an important fact that the point of supply can be at the center of a low-pressure main feeding both ways from this center. This also contributes materially to reducing the low-pressure piping cost, which, together with other items, is of great value to investors as well as building operators.

An example of a zoned system is shown in Fig. 4, and is illustrative of the condition in many industrial plants. The occupants of the office, because of their limited physical activity, require a temperature of about 70 deg. F. for comfort, while those in other factory departments are satisfied with a temperature of about 65 deg. F. With the zoned system the steam supply can be regulated so that the temperature in the various departments is maintained to suit the working conditions.

[1]Described in *Power*, March 20, 1928.

How One Engineer Cares for His Heating System

By T. Welmer

THE heating system in question serves a group of about twenty buildings, six to nine stories high, scattered over four city blocks. The systems are of various types ranging from one-pipe gravity, two-pipe gravity, two-pipe vacuum and mixed systems. Some buildings have air-line systems with vacuum on air lines, some have vacuum on the return line, and some have merely an automatic air valve discharging to atmosphere in the room.

About one-third of the buildings are equipped with temperature regulation. The diaphragm valves in the system are carefully gone over during the summer months, renewing hardened rubber diaphragms and repacking valve stems. However, the rubber diaphragms are being replaced with metal ones as fast as funds and time are available.

Air leaks in the vacuum lines are sometimes hard to find, as the pipes are buried in the floors and walls. They are found by stopping the vacuum pumps, increasing the steam pressure on the heating system and then watching for stained ceilings or water leaks. As a rule the ceiling has to be broken up to get at the leaks, so it makes little difference whether the ceiling gets wet or not.

Only one man is allowed to adjust the return traps and air valves in order to obtain a uniform setting and to prevent overheating of the return mains and loss of vacuum. In some of the larger buildings the vacuum lines have been sectionalized and an ejector installed for each section in order to better regulate the vacuum. On mild days when only one wing of a building requires heat, the ejector pulling the air from the radiator of that wing is operated and the other radiators remain airbound. In one of the buildings the air from the ejector is discharged back into the heating system and the radiators filled with a mixture of air and steam.

Early in the spring all the risers supplying halls are shut off in order to save steam. In the buildings equipped with vacuum return lines, air is admitted during mild weather through a check valve into the steam main, thus filling the system with a mixture of steam and air, partly airbinding the radiators and reducing the amount of steam they condense. As the average occupant of a room will not shut off a radiator or throttle a modulating valve, but, instead, opens a window in order to cool off a room that has become too warm, the coal saving depends largely on regulation by the engineering force.

On new work we use the more recent types of valves and radiator traps, but still have a large number of the old-style carbon plug return and air valves giving good service. When a carbon plug is found swelled or buckled, it is replaced with a new one and the damaged plug turned up in a lathe to the original size and shape, and when used again, it appears to give as good service.

Two books are kept on the engineer's desk, one a "want" book in which is jotted down any material that is needed, the other a "work" book in which are entered all repairs to be made or changes that appear desirable. With these books on hand, it is always possible to find work for the repair crew or to check up on material requisitions.

WATER POWER *Development*

Records Many Advances

THERE are still tremendous opportunities in this country and Canada for hydro-electric developments, as shown by recent government reports from the two countries. According to the latest report of the Department of the Interior, Canada, there is now installed about 5,000,000 hp. in water-power plants in that country. At ordinary six-months flow the latest figures show an available horsepower of over 33,000,000. On the present basis of development this would warrant the installation of about 43,000,000 hp. capacity in waterwheels.

A recent report of the United States Geological Survey shows that there is installed in the United States 12,300,000 hp. of waterwheels. This same report indicates that nearly 60,000,000 hp. is available, based on ordinary six-months stream flow. If it were feasible to develop all the water-power sources of the United States, the total capacity of waterwheel that would be installed is placed at 85,000,000 hp. The combined figures of the United States and Canada for water-power development would indicate that in these two countries there is still a possible market for over 100,000,000 hp. of waterwheels, not considering the capacity necessary to replace old and obsolete developments.

PROJECTS of record size and for record heads, changes in plant design to reduce construction costs and automatic stations of unprecedented size.

Cheap fuels, increased efficiency, low construction costs and proximity to load centers and other causes have recently given steam an advantage over the water-power plant that it did not have a few years ago, in many localities. Notwithstanding this, hydro-electric plants continue to supply about 36 per cent of the power generated in central stations.

Although during the last year the new projects started have been below normal, a number of developments have been completed or are nearing completion that record marked progress in design, both for size and in new features.

Outstanding in size is the Conowingo development, on the Susquehanna River near Baltimore. This plant is laid out for eleven 54,000-hp. units operating under an 89-ft. head at 81.8 r.p.m. The initial development has seven units, which have the largest physical dimensions of any wheels so far constructed. This plant, with its initial installation, will produce one and a quarter billion kilowatt-hours, which represents an annual saving of more than three-quarters of a million tons of coal.

In high-head plants the two 56,000-hp. units to operate under a head of 2,290 ft., represent a record for this class of equipment. These machines are being installed in the Big Creek 2A plant of the Southern California Edison Company. They are of the double-overhung impulse type, with the generator between the two wheels. The total weight, 700,000 lb., of the rotating element is carried on two ring-oiled type babbitted bearings 7 ft. long by 32 in. in diameter.

To keep down the cost of construction various types of designs have been developed. At the Falls of the Ohio, near Louisville, Ky., a plant recently went into operation in which all the equipment is housed within the limits of the generator room. This plant contains eight 13,500-hp. units driven by propeller-type wheels, operating under a head of 37½ ft. In this plant the busbars are carried along one wall of the generator room and the conventional type of switchboard has been replaced by individual control panels installed in cabinets alongside each generator. Supervisory control permits the chief station attendant to supervise the switching throughout the entire station. Other installations have been designed with a low building just sufficient to house the generators, the crane being placed above the roof. In other installations the superstructure of the power house has been omitted entirely, the generators being provided with a covering to protect them from the weather. One of the outstanding installations of this kind is the Norwood development of the Carolina Power & Light Company, where three units aggregating 88,000 hp. are of the outdoor type. At the Lewiston, Idaho, plant of the Inland Power Company, two 7,000 hp. units of this type have been installed.

Automatic power stations continue to be built in increasing sizes. The Glines Canyon station of the Northwestern Power & Light Company in Washington, which went into operation about a year ago, is the largest plant so far operated without an attendant. The unit is rated at 19,500 hp. under 180 ft. head and is under supervisory control from another station 7½ miles away.

The Rocky River plant of the Connecticut Light & Power Company represents an unusual development in this country, in that water is pumped into storage during flood and off-peak periods, to be used for power development on peak loads. This plant contains one 33,300-hp. hydro-electric generating unit and two 8,100-hp. centrifugal pumps. The maximum head will be 240 ft. Although this is the first plant in this country to pump water, in Europe some 40 stations are in operation, under construction, or have been projected. In view of these developments it appears that there is no reason why this type of plant should not find a wide use in this country, when its economic features are better understood.

Another European development, the roller-type gate, which was introduced into this country a few years ago, is being applied to a number of important installations. At the Bellows Falls, Vermont, hydro-electric development of the New England Power Association there are installed, on the crest of the dam, two of these gates that are 18 ft. in diameter and 115 ft. long.

Plant at Dam No. 7 on the Kentucky River, contains three 650-kva. generators driven by propeller-type turbines operating under a 15-ft. head

The generators in the power house on top of the three piers are connected to the waterwheels in the dam by a vertical shaft in each pier. Equipment is handled through hatches in the plant's roof by an outdoor crane

Possible Improvements in Design To Reduce Cost of Hydro-Electric Projects

By L. F. Harza
Consulting Engineer, Chicago, Ill.

THE close competition that has developed between power produced in hydro-electric and in steam plants, emphasizes the need of working for maximum economy in the development of water powers. In order that this economy may be realized, it will be necessary first to overcome at least some of the natural conservative tendencies of the engineer to do the conventional thing rather than to rely upon independent thinking. The process of a gradually improved economy and simplification has been in progress for a number of years, but it is necessary that further improvement be made.

One outstanding simplification that has been used for many years is the outdoor substation and switching station, which costs much less than when the equipment is inclosed by four walls and a roof. This construction has become standard in nearly all climates.

The high-specific-speed or propeller-type turbine came into use some ten years ago. This type saves no cost in the turbine itself, but allows a reduction in the cost of the generator due to the higher speed. A reduction in first cost often appeals to the non-engineer executive much more strongly than any prospective and less tangible increase in earnings, which might justify more expensive equipment.

An objection to the propeller runner is its low part-gate efficiency. This type of turbine is justified for installations where a unit can run at the gate opening yielding best efficiency or be shut down entirely. It also possesses favorable characteristics for operation where low-head conditions exist for long periods, under which conditions the power of the propeller-type unit falls off less than the Francis turbine.

With the increasing size of the interconnected systems, where the load carried by an individual generating unit becomes a smaller and smaller proportion of the total load on the system, it becomes increasingly feasible to operate some units of a station or some stations of a system at the most efficient load or to shut them down until sufficient water has accumulated in the forebay to resume operation at the most efficient load. The gain in output by this program where it can be applied may be large.

Outdoor units have been attempted in two or three cases; that is, generating units operating without the protection of the roof or building superstructure. Reports differ as to their success and conveniences.

Generators built by welding structural shapes are being used as an economy in construction. The economic value of this construction will be determined by the prices its advocates are able to make to the trade in competition with machines built with conventional all cast frames. Similar methods might perhaps be applied to waterwheels.

It is suggested that building superstructures can be reduced to a low height, merely clearing the tops of the generators. With this construction the machinery is handled through a hatch in the roof by means of a gantry crane traveling out of doors over the roof. This is in contrast to the usual design that requires a building high enough to inclose a traveling crane with sufficient clearance above the machinery to remove it underneath the roof. Such designs have been employed successfully at Mitchell Dam in Alabama and recently at Dam No. 7 on the Kentucky River, Kentucky.

The biggest single item of cost in a hydro-electric development is usually the dam. Effort has been made for many years to reduce the cost of construction, which has resulted in numerous applications of flat-slab hollow concrete dams, multiple-arch dams of many designs, constant-radius arch, constant-angle arch designs. There is no type that is a panacea for the ills of the more conventional gravity concrete dam. In fact, a dam that will prove cheapest under some circumstances, will be much more expensive when used under another combination of conditions.

There is no simple type of dam that is even physically feasible at all sites, much less is there any type that is always the most economical or best adapted. There are some engineers who will build nothing but a gravity concrete dam; others, nothing but a multiple-arch; others, nothing but a flat-slab hollow concrete dam; others, a constant-angle arch, etc., frequently, because of some patent claim which they hold. Such procedure, however, is not engineering, but salesmanship in disguise.

There is a tendency among some engineers to recommend only a structure of monumental type, such as a gravity concrete dam, which they feel will reflect glory and renown upon themselves. Such engineers usually reject proposals for earth dams and some other cheaper types. An earth dam, if properly built for existing conditions, where these conditions are appropriate, is as safe and permanent as any engineering structure can be. For example, the opinion may be ventured from such information as has been published regarding the St. Francis dam failure, that an earth dam could have been built at that place with entire safety and permanency, provided suitable material were available.

Many minor economies are being made and will continue to be made which will serve to reduce the cost of hydro-electric generating stations. Yet there is, in my opinion, one feature that offers greater possibilities than any other single factor and applies to all structures. I refer to the improvement that has been made in recent years in the design and control of concrete mixtures that go into the structures.

Engineers from long habit are accustomed to building hydraulic structures of massive proportions, depending largely upon weight and allowing liberally in their designs for disintegration and weathering. Through the work of Duff Abrams, of the Portland Cement Association, the design and control of concrete has been put upon such a scientific basis that the resulting strength can be assured in nearly all instances within 10 per cent of design requirements. Under such conditions the so-called "factors of safety," more correctly called "factors of ignorance," can be reduced below former practice with fully as great a degree of safety as formerly accompanied the design of heavier and more massive structures. The better grade of concrete resists weathering and disintegration in addition to furnishing the higher permissible unit stress resulting in less massive structures and savings in material.

ALTHOUGH the use of higher-speed units, improved methods of machine construction and changes in power-house design may serve to reduce the cost of water-power developments, in the author's opinion improvements that have been made in the design and control of concrete offer greater possibilities than any other single factor, and this applies to all structures. A feature greatly in favor of economic hydro-electric plant operation is the interconnected system, which allows of operation best suited to a particular plant.

The most significant fact, however, which will probably continue for many years to justify the development of hydro-electric powers of medium and high heads, almost regardless of any prospective reduction in steam cost, is the fact that interconnection has relieved the hydro-electric plant of the necessity of operating as an independent generating unit. Simultaneously with the reduction in the steam cost has come interconnection, and interconnection makes possible the operation of any generating plant of a system more nearly in the manner for which it is best suited.

A hydro-electric station is best suited for operation on peak load, because after the initial construction of the dam and hydraulic works, the cost of additional generating capacity, or multiplication of generating capacity for peak-load service, costs less than steam capacity, where the hydro station is for a head of 25 ft. or more.

A hydro-electric plant complete with generating equipment, and including substructure and superstructure for a head of 100 ft., but not including the dam, costs only about one-half that of an equivalent steam generating station. Hydro-electric stations with forebay storage can, therefore, best store their water for peak-load hours. Moreover, a hydro unit can be brought into service in the period of one or two minutes without any preliminary preparation, another great advantage for peak-load service.

The advantages of medium- and high-head hydro-electric stations with forebay storage over a steam system are so great as to permit this type plant, when property designed for this service, to maintain an equally important place in the industry, with the growth of the interconnected systems, with that which water-power stations once enjoyed because of their cheaper energy cost.

PLANT EQUIPMENT NEWS

New and improved equipment in power and industrial plant fields, and new applications of existing equipment

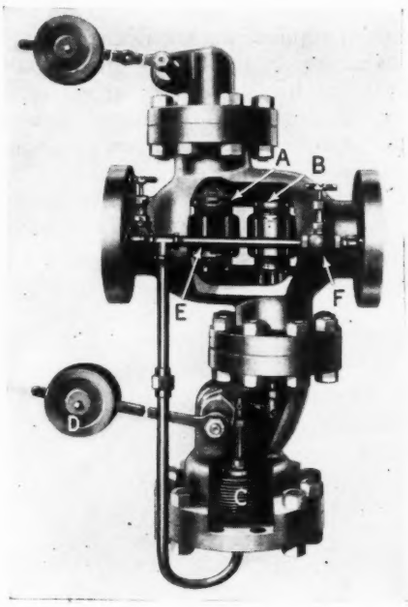
Copes Type RG Valve

IN THE report of the Chicago Power Show mention was made of a combined feed-water regulator and pressure regulating valve brought out by the Northern Equipment Company, Erie, Pa. Further details of this valve are given herewith.

Referring to the illustration, two valves, *A* and *B*, are placed side by side in the single body casting. The valve *A* is a standard Copes feed-water regulating valve operated by the Copes thermostat, and controls the amount of water delivered to the boiler according to the requirements of evaporation and water level.

The valve *B* is operated by a sylphon bellows *C* and is designed to control the water pressure differential and to give a constant excess pressure on the line side of the regulating valve *A*.

The initial, or feed-line, pressure is on the outside of the bellows, and the discharge or boiler pressure is on the inside, thus the bellows is subjected to the differential water



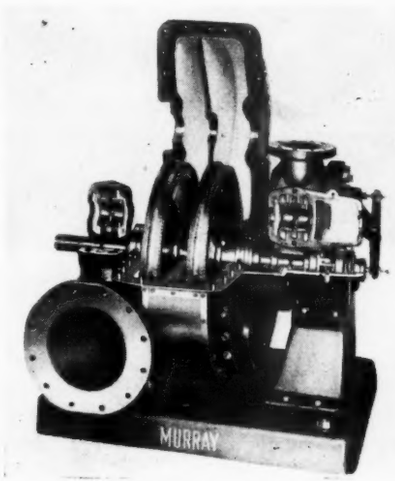
Combined feed-water and excess-pressure regulating valve

pressure, the differential being determined by the position of the weight *D*, on the lever arm.

The connection *E* with the two valves, serves as a bypass when filling or cleaning the boiler, the valve *F* being closed when the valve is in normal operation.

New Frame Sizes of the Murray Turbine

IN THE accompanying illustration is shown one of a number of frame sizes of steam turbines that have been designed by the Murray Iron Works Company, of Burlington, Iowa. The particular turbine shown, which is designated as frame E, is designed for capacities up to 800 hp. at 3,600 r.p.m., and for high pressures and superheats. The frame is nozzled for 200 hp., but owing to the needle valve construction of the nozzle, additional valves may be added to give an appreciable increased output.



Murray standard turbine, frame E size

The machine shown is a two-stage impulse turbine having two 2-row velocity stages, and a new design of pedestal bearing construction with a sliding support under the steam end. Besides giving rigid and substantial support for the bearings, this construction compensates for expansion and tends to prevent vibration and misalignment.

An exceptionally heavy shaft is provided, the one in the picture being 4 in. in diameter. For control, the turbine is equipped with constant speed and emergency governors operating independently on independent valves. The bearings are made of Sumet metal, and the nozzles, blading and governor valves and valve seats are Monel metal. Other frame sizes of this new turbine soon will be available.

Bayley "Chinookfin" Unit Heater

IN THE Chinookfin unit heater recently brought out by the Bayley Blower Company, 732-753 Greenbush St., Milwaukee, Wis., each tube is an individual radiator and is free to expand or contract separately from other tubes in the heater.

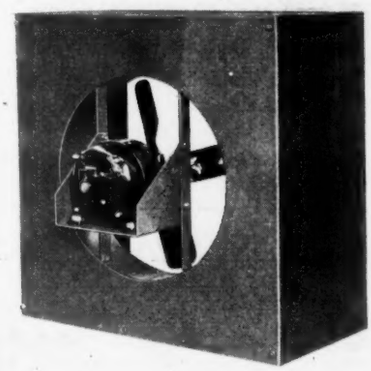


Fig. 1—Welded steel casing with fan

The base of the heater is a casting divided horizontally into chambers. From the lowest chamber small pipes extend up within the radiating tubes. These pipes are open at both ends, and their function is to carry the steam from the steam chamber to the outer end of the radiating tubes. These circulating pipes are screwed into the partition that separates the base into two chambers. The radiating surfaces are copper tubes having extended copper fin surfaces.

Each radiating tube is expanded into a special bushing and belled at the end. The bushing is then screwed into place in the base casting, the other ends of the tubes being supported in a channel permitting free movement of the individual tubes. This construction assures flexibility and facilitates removal and replacement of any one tube without

removing other tubes in the heater. The complete radiating section is inclosed in a welded steel casing with a motor-driven disk fan mounted in the center, as shown in Fig. 1.

The unit is light in weight and can

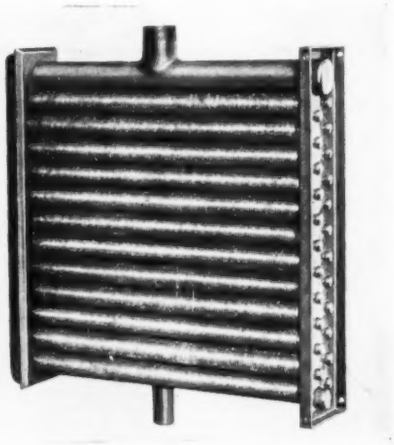
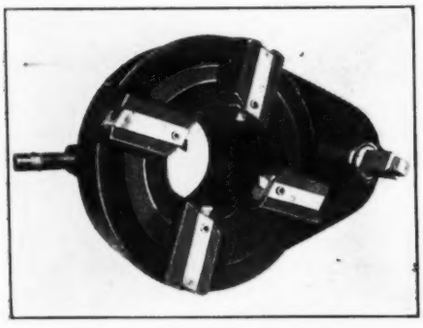


Fig. 2—Radiating element of heater

be supported directly from the pipe line, if desired. It can be installed singly or a number can be combined into one unit to give the capacity required.

Toledo No. 80 Automatic Pipe Cutter

IN THE Oct. 18, 1927, issue the new automatic pipe cutter No. 40 for 2-in. to 4-in. pipe sizes brought out by the Toledo Pipe Threading



Cutter for 4½-in. to 8-in. diameter pipe

Machine Company, Toledo, Ohio, was illustrated and described. This company has since brought out the No. 80 cutter illustrated herewith, for pipe in sizes from 4½-in. to 8-in.

As pointed out in the previous description, this machine is designed to give a straight square-end cut with the outside edge chamfered to facilitate the starting of the die. The knives are fed automatically, requiring no attention on the part of the operator. A single handwheel sets them for cutting or the quick return of the knives after the pipe is cut off.

The cutter is operated either with the regular ratchet handle furnished with the Toledo No. 2 or No. 25 threading tools, or with a Toledo power drive.

Griscom-Russell Bent-Tube Heat Exchanger

THE illustrations show a type of cooler and condenser recently brought out by the Griscom-Russell Company, 285 Madison Ave., New

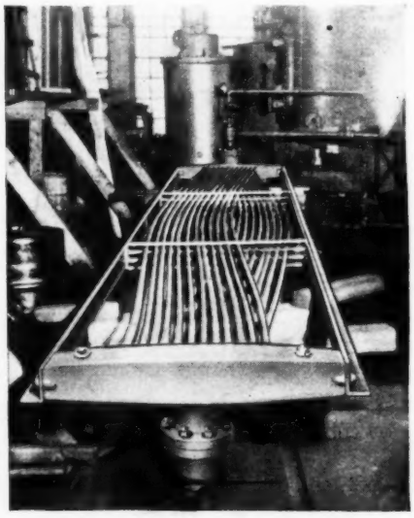


Fig. 1—Section under test with tubes at maximum deflection

York City, in which is embodied the curved-tube principle introduced by this company about two years ago in its bent-tube evaporator. The function of the bent tube is to facilitate the removal of the scale from the tube by cracking.

The new cooler consists of a series of Admiralty metal tubes set with an initial curvature into cast-iron headers at each end, the headers being permanently spaced by angle-iron sections at each side.

The liquid or gas to be cooled or vapor to be condensed, as the case may be, passes through the tubes and the cooling effect is obtained either by pouring water over the tubes, from distributing spray nozzles or a cooling tower set above them, or by submerging the entire unit in a tank of water.

The way in which the bent tube principle tends to keep the tube free of scale will be apparent from a study of Fig. 1, which shows a cooler section under test and the tubes at about maximum deflection.

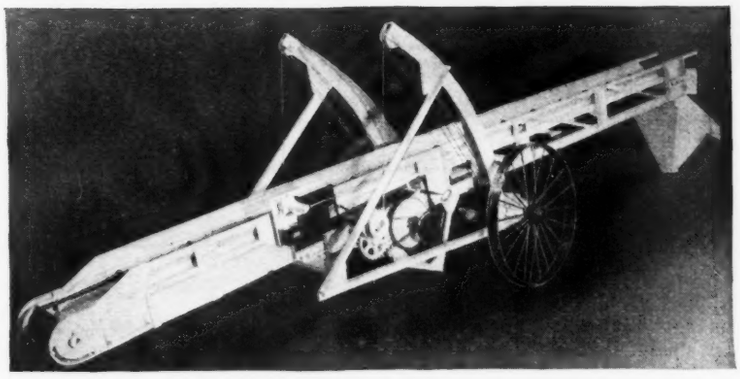
In operation, when the hot liquid, gas or vapor passes through the tube, the resulting expansion greatly accentuates the initial bowing of the tube about as shown in Fig. 1. If the flow of the hot liquid is interrupted, the tubes again contract to their initial curvature and this change in curvature is made use of to crack off the scale.

Changes in curvature on the tube may be accomplished either by stopping the flow of cooling water, while the hot liquid continues to pass through the tube, or by stopping the flow of the hot fluid while the cooling effect is continued.

This scaling feature is advantageous in applications where the cooling-water supply is of poor quality, and may be used for cooling oil, gas, jacket water and industrial liquors or for condensing steam or vapors of various oils and chemicals.

The units are made interchangeable and by simply installing additional sections, may be arranged in parallel to permit increase in capacity or stacked in series to give greater cooling effect.

Fig. 2—Unit sections stacked in series



Flight conveyor with capacity of 60 to 90 tons of coal per hour

Gifford-Wood Portable Flight Conveyor

THE Gifford-Wood Company, Hudson, N. Y., has recently brought out the portable flight conveyor lilustrated known as the type "D."

The machine, which is adaptable for handling all sizes and grades of coal as well as coke and similar materials, has a handling capacity of 60 to 90 tons of coal per hour, depending on the grade and size handled. It is made in three lengths: 20, 25 and 30 ft. The flights are 15 in. wide and 4 in. high and are suspended between two strands of $2\frac{5}{8}$-in. pitch steel and malleable-iron combination sprocket drive chain.

This machine is equipped with a power raising and lowering device, which can be operated with the conveyor in operation. Swivel wheels give added flexibility when maneuvering the machine into narrow spaces and also allow the machine to be used for stacking out coal in radial piles.

The drive mechanism and motor are placed to the rear of the center of the machine under the boom. This confines the bulk of the weight to a point close to the loading end and permits the head end to project a greater distance beyond the wheels. This latter feature makes it possible to stack out coal to the full height of the conveyor without burying the wheels.

Two compression clutches are provided on the drive mechanism—one for throwing the conveyor in and out of service without starting and stopping the motor, the other for operating the raising and lowering mechanism. The boom can be raised while the conveyor is handling coal by merely throwing in the clutch that operates the raising mechanism. To lower the boom, the conveyor clutch is thrown out and the motor reversed before the clutch on the lowering mechanism is thrown in.

National Cartridge Air Filters

TO PROVIDE a simple and convenient filter for cleaning the air for small compressors, the National Air Filter Corporation, Chicago, Ill., has brought out the line of cartridge filters illustrated, in capacities from 150 to 800 cu.ft. of air per minute.

Cartridge filters with capacities from 150 to 800 cu.ft.

The filters are simply small drums with the entire circumference of the drum covered with the filtering medium, and having a screw connection on one end for attaching to the compressor air-intake pipe. The filtering medium comprises layers of expanded metal and of twisted copper ribbon of woven fabric, the whole being immersed in oil before attaching to the pipe.

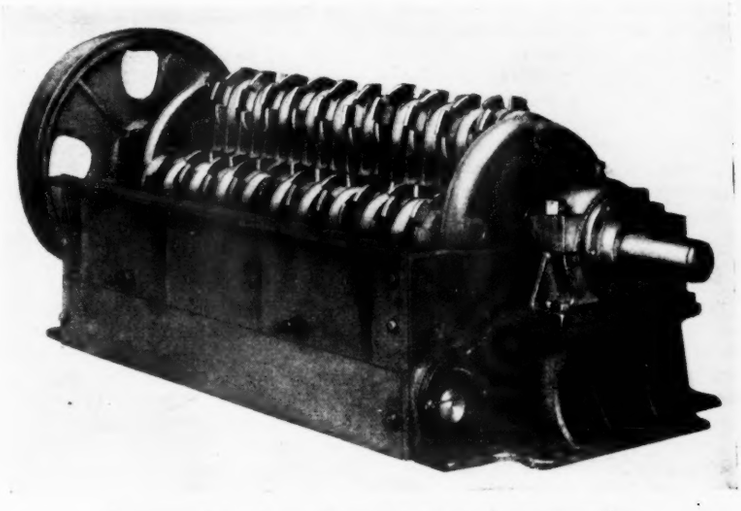
The cartridge is readily cleaned at intervals by unscrewing it from the pipe by means of a handle on the closed end, and placing it in a steam jet or in hot water, finally immersing it in oil before replacing on the pipe.

Improved American Ring Coal Crusher

THE American Pulverizer Company, 1249 Macklind Ave., St. Louis, Mo., has recently added to its line of coal crushers the improved ring crusher illustrated.

In the new line, which is designated as the S series, the crushers are of cast-steel construction with manganese grinding parts and an alloy steel shaft of liberal diameter. The shaft is carried in anti-friction tapered-roller bearings mounted on heavily ribbed end castings.

The cast-steel housing of the machine is reinforced with ribs and all parts are machined and are interchangeable. Adjustment for the size of product desired is made by means of an eccentric grinding plate. The machine is protected from tramp iron by the rolling-ring principle of crushing employed, as on other machines made by this company. The new line is made in a number of sizes.



Improved coal crusher of cast-steel construction

NEWS OF THE FIELD

The editors will welcome the co-operation of readers in reporting interesting happenings, personal or otherwise

Program of N. E. L. A. Convention Contains Variety of Subjects

An attendance of 10,000 is expected to hear many prominent speakers scheduled to address the meeting

A WELL-ROUNDED program, broad in its coverage of the problems of the industry, has been arranged for the National Electric Light Association's Fifty-First Convention and exhibition, to be held at the Million Dollar Pier in Atlantic City, June 4 to 8. New light will be shed on interconnection and the function of the holding companies; research, electrical advertising, and commercial outlook and merchandising problems, will be featured; while engineering, accounting and public relations subjects will have careful consideration. An imposing array of speakers will address themselves to these subjects, and a thoroughly successful convention is foreseen.

This year's exhibition will surpass all previous ones held in the twenty-one years of the Exhibition Committee's existence. Every available inch of space on the huge Million Dollar Pier, not occupied by the Convention Hall, offices and special booths, will be taken up by the 206 manufacturers, all of whom will have a most comprehensive display of electrical apparatus.

Program Outlined

The six general sessions of the convention will be held in the main ballroom of the Million Dollar Pier, on the mornings of Tuesday, June 5, Wednesday, June 6, Thursday, June 7, and Friday, June 8, and on the afternoons of Wednesday and Thursday.

The public policy meeting is scheduled to be held Wednesday evening, June 6. At this session the Charles A. Coffin Award will be presented by Girard Swope, president, General Electric Company. The special entertainment that is provided for this session will be broadcast through the courtesy of the National Broadcasting Company.

Simultaneous sessions of the Public Relations, Engineering, Accounting, and Commercial Sections, will meet Tuesday afternoon, June 5. The Engineering Section will be under the chairmanship of E. T. Stone, chairman, Engineering National Section, Duquesne Light Company, Pittsburgh, Pa. Four addresses are to be given at this session: "Purposes and Accomplishments of The Engineering Staff," by H. S. Bennion, Director of Engineering, N. E. L. A.; "Organizing The Industry's Engineering Research," by A. D. Bailey, superintendent of generating stations, Commonwealth Edison Company, Chicago, Ill.; "Spending Our Company's Money," by W. E. Mitchell, vice-president, Georgia Power Company, Atlanta, Ga.; "Engineering for the Future," E. T. Stone, manager, system development department, Duquesne Light Company, Pittsburgh, Pa.

The president's reception and ball will be held Monday evening, June 4, in the main ballroom of the Pier. The entertainment committee has arranged features to fill in the time between business meetings and for the entertainment of the ladies.

Bachrach

H. T. Sands, President N.E.L.A.

Sidney V. Mitchell, Electric Bond & Share Company, New York, is honorary chairman of the general convention committee, and H. G. Sands, Electric Bond & Share Company, New York, is chairman. The vice-chairmen of the general committee are: D. S. Arkwright, Georgia Power Company, Atlanta; John G. Miller, California Edison Company, Los Angeles; M. S. Sloan, Brooklyn Edison Company, Brooklyn; W. A. Jones, Henry L. Doherty Company, New York; and P. S. Young, Public Service Electric & Gas Company, Newark, N. J. Thomas Sproule is chairman of the Exhibition Committee.

Milwaukee to Have Second High-Pressure Unit

By November 1 the capacity of the Lakeside Station of the Milwaukee Electric Railway & Light Company will have been increased from 167,000 kw. to 234,700 kw., when two machines now in contemplation are ready for operation. One of the new machines is to be a 60,000-kw. single-barrel, Westinghouse turbine-generator unit provided with four-point extraction for feedwater heating and equipped with a single-pass condenser. Steam conditions will be 300-lb. pressure and 725 deg. F. The other is to be a 7,700-kw. machine to operate at 1,250-lb. pressure that will increase the capacity of the high-pressure section of the station and at the same time provide a reserve for the first high-pressure unit installed in this plant. Sufficient boiler capacity is already available. The second machine will be practically a duplicate of the first.

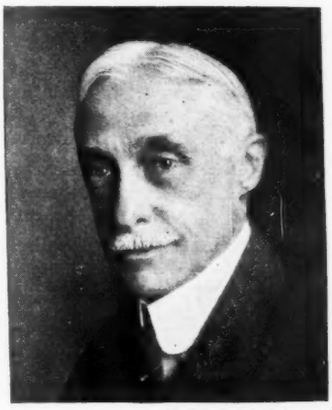
Owing to some minor mechanical troubles with the turbine, packing no organized test up to the time of writing has been conducted on the high-pressure equipment, and it may be that such a test will not be necessary in view of results that have been obtained in service. During February, when the high-pressure section was in continuous operation for the full period, carrying 29 per cent of the total station output and operating on approximately 95 per cent load factor, the effect was a reduction in over-all station B.t.u. per switchboard kilowatt-hour, from 15,800 to 14,800 B.t.u. To reach the latter figure for the station, necessitated that the high-pressure section produce a kilowatt-hour on 12,500 B.t.u. Improving the station economy by 1,000 B.t.u. per unit of output is considered equivalent to a saving of $10,000 per month, or $120,000 per year.

Holston River Project to Develop 48,000 Hp.

Application has been made by the Tennessee Eastern Power Company to the State Railroad and Public Utilities Commission, Nashville, Tenn., for authority to build a $5,200,000 dam and power plant on the Holston River. The development would create a reservoir covering more than 2,500 acres in Sullivan and Washington Counties, it is said, extending about eight miles up the Holston and four miles up the Watauga River.

The dam would be constructed on the south fork of the Holston about eight

miles below the junction of the Holston and Watauga Rivers, and would range in height from 100 to 110 ft., according to estimates, and would be capable of producing 48,000 hp. Construction would be started within 18 months and the project completed within three years. The Tennessee Eastern Power Company has been organized with 90,000 shares of common stock and is controlled by Henry L. Doherty & Company, New York. Its officers include W. A. Jones, president; R. E. Durger, vice-president.



Underwood & Underwood

ELMER A. SPERRY

Nominated for president of A.S.M.E.

AT its spring meeting in Pittsburgh the American Society of Mechanical Engineers nominated for president Elmer A. Sperry, recipient of the Holley Medal and nationally known as the inventor of the gyro-compass and gyroscopic ship stabilizer. Mr. Sperry is now chairman of the board of directors of the Sperry Gyroscope Company.

N.A.P.E. Holds New York Convention June 7-9

The committee in charge of the state convention of the National Association of Power Engineers have nearly completed final arrangements for that gathering, June 7, 8 and 9, at Syracuse, N. Y.

Inspection trips and sight seeing tours will be part of the delegates entertainment. Several industrial plants, whose products are of interest to the engineer, will be visited, and Central New York, abounding in scenic beauty will be shown the visitors.

The power show, featured at all N.A.P.E. conventions, will be top-notch, with a wide and varied range in exhibits.

The banquet held on the evening of the ninth, at the Onondaga Hotel, convention headquarters, will be replete with good food, entertainment, and excellent after-dinner speakers; National President Bassett, State President Diebold, and many other noteworthy N.A.P.E. men being listed.

A. S. H. & V. E. Anticipates Record Meeting at West Baden Springs

FOR the first time in its history the American Society of Heating and Ventilating Engineers will meet at West Baden Springs, Ind., for its summer meeting. Prof. A. C. Willard, president of the Society, expects this meeting will break all records, as West Baden is one of the Middle West's most attractive resorts, and the technical program prepared by Prof. F. B. Rowley contains many unusual features.

One of the big events of the meeting will be the report of the committee on the Code for the Rating and Selection of Low Pressure Boilers. At a meeting in New York May 8, the committee decided to make final report after its year and a half work, during which time it has held numerous conferences and conducted several researches. The committee feels that a code has been prepared which is of practical value to the manufacturer and useful to the engineer, architect and heating contractor.

It is anticipated that a permanent committee will be formed to administer, interpret and revise the code as occasion requires.

Another code of importance is that produced by E. K. Campbell's Committee for the Heating and Ventilating of Garages. This committee's recommendations have been submitted to the National Fire Protection Association and were adopted at the last meeting of that organization as a tentative standard.

A great many reports of recent laboratory investigations are to be made at the meeting, and similar subjects are to be reported on by field workers. Two reports on heat transmission are to be made, three on air infiltration, two on gas heating, and two on furnace heating.

In his paper on the "Operation of Equipment in Federal Buildings," Nelson Thompson has given some useful data that every engineer will find of interest, and in the field of air conditioning, several papers have been offered.

A paper of unusual interest is that by D. E. Humphrey, in which he describes the process of making gas bags for airships and explains the great care that is necessary in the preparation of gold beater's skin. Ventilation plays a considerable part in the process of manufacture.

There is no doubt that the technical program is one of exceptional merit.

The first item on the social program for the summer meeting is the luncheon for officers and authors of papers which is to be held at noon on Tuesday, June 26. This affair will give an opportunity for these men to become better acquainted and will no doubt result in a more interesting presentation of papers. On Tuesday evening there will be an informal reception and dance, which will be held in the West Baden Springs Hotel. The hotel's fine dance orchestra will play.

Promptly at 2:30 on Wednesday afternoon Chairman Fenstermaker will gather his golfing legions for the medal play tournament, and at the end it will be determined who won the Research Cup, now held by Alex McClintock, of Philadelphia.

One of the big events of the meeting comes at 7:30 p.m. on Thursday, when the banquet and dance will be held. One of the events of the evening will be the awarding of the golf prizes, and during the evening music for dancing will be furnished by the hotel orchestra.

A complete outline of the program follows:

TUESDAY MORNING, JUNE 26,

Registration and Committee Meetings; Luncheon for Officers and Authors.

TUESDAY AFTERNOON

Greeting by Pres. A. C. Willard; "Development of Gas Heating for Homes," by W. E. Stark; "Methods of Calculating Cost of Gas Heating," by A. E. Stacey, Jr.; "Operating Data on Federal Buildings," by Nelson Thompson.

TUESDAY EVENING

Council Meeting; Informal Reception and Dance.

WEDNESDAY MORNING, JUNE 27

"Warm Air Heating System for Industrial Buildings," by J. C. Miles; "Relative Consumption of Various Solid Fuels in Residence Heating," by V. S. Day; "Domestic Oil Burner Design and Performance," by W. C. Tarnahan; "Heat Transfer Through a Roof Under Summer Conditions," by F. C. Houghten and C. G. Zobel; "Heat Transmission Research," by F. B. Rowley.

WEDNESDAY AFTERNOON

Golf Tournament (Research Cup); Ladies Bridge and Tea; Moving Picture Film (White Sulphur and New York Meetings).

THURSDAY MORNING, JUNE 28

Discussion of Code of Boiler Rating and Selection; Discussion of Code for Heating and Ventilating; Garages; "A Study of Dust Determinators," by F. B. Rowley; "Methods of Air Distribution," by L. L. Lewis; "Thermal Exchanges Between the Human Body and Its Atmospheric Environment," by F. C. Houghten.

THURSDAY AFTERNOON

Golf Tournament—Ladies and Men; Trip to Marengo Cave for Ladies.

THURSDAY EVENING

Semi-Annual Banquet and Dance.

FRIDAY MORNING, JUNE 29

"Air Leakage Through a Pivoted Window," by F. C. Houghten and M. E. O'Connell; "Infiltration Through Steel Windows," by J. E. Emswiler and W. C. Randall; "Effect of Storm Windows and Frame Calking on Infiltration Through and Around Windows," by W. N. Richtman and C. Braetz; "Heating and Ventilating Problems of Gas Cell Manufacture for Air Ships," by D. E. Humphrey.

J. H. Kinealy, Past-President of A. S. H. & V. E., Dies

John Henry Kinealy, charter member and past-president of the American Society of Heating and Ventilating Engineers, and widely known as a mechanical engineer, died at the Christian Hospital, St. Louis, Mo., May 6, at the age of 64 years.

Mr. Kinealy was born in Hannibal, Mo., and attended public and private schools of St. Louis, later graduating from Washington University with the degree of mechanical engineering. For five years after graduation he was an instructor in engineering at Washington University and an associate professor of engineering at the Agricultural and Mechanical College of Texas. In 1902 he went to Boston to practice as a consulting engineer. After several years there he returned to St. Louis and practiced his profession in that city. He was active in association and community affairs and served the American Society of Heating and Ventilating Engineers as its president in 1901.

He was the author of many articles and scientific papers on heating, ventilation and hygiene, also of a number of books, including "Steam Engines and Boilers" 1895 (Fourth Edition, 1903); "Charts for Low Pressure Steam Heating," 1897; "Formulas and T bles for Heating," 1889; "Slide Valve Simply Explained," 1899 (American Edition); "Centrifugal Fans," 1905; and "Mechanical Draft," 1906.

New Policy Announced for Midwest Power Show

In announcing Feb. 12-16, 1929 as the dates for the fourth Midwestern Engineering and Power Exposition at Chicago, Midwestern Engineering Exposition, Inc., has also set forth a new policy covering a period of five years, with shows in 1929, 1931, and 1933.

These dates have been selected in order to conform to the desires of several manufacturers for a biennial instead of annual shows. Should, however, there be any further activity required the management states they will put the matter to a referendum of the exhibitors and follow their wishes as far as it is practical to do so under the conditions thus existing.

Coming Conventions

American Association of Engineers, annual convention, El Paso, Texas, June 4-6; M. E. McIver, secretary, 63 Adams St., Chicago.

American Boiler Manufacturers Association, annual convention, at Buckwood Inn, Shawnee-on-the-Delaware, Pa., June 11-13; A. C. Baker, secretary, 801 Rockefeller Bldg., Cleveland, Ohio.

American Institute of Electrical Engineers, annual Summer convention at Denver, Colo., June 25-29; F. L. Hutchinson, secretary, 33 West 39th St., New York City.

American Order of Steam Engineers, convention at Atlantic City, N. J., June 11-14, and exhibition with American Supplymen's Association. Address Fred L. Jahn, Watson of McDaniel Company, 146 N. Seventh St., Philadelphia.

American Society of Refrigerating Engineers, meeting at Detroit, June 4-7; W. H. Ross, secretary, 37 West 39th St., New York City.

American Society of Heating and Ventilating Engineers, Summer meeting at West Baden Springs Hotel, West Baden, Ind., June 26-29; A. V. Hutchinson, secretary, 29 West 39th St., New York City.

American Society of Mechanical Engineers, first national oil and gas power meeting at State College, Pa., June 14-16; Twin-City regional meeting at St. Paul, Aug. 27-30; Boston regional meeting, Oct. 1-3; second national fuels meeting at Cleveland, Ohio, Sept. 17-20; Calvin Rice, secretary, 29 West 39th St., New York City.

American Society for Testing Materials, Atlantic City, June 25-29.

American Water Works Association. Annual meeting, Hotel Fairmont, San Francisco, June 11-16; W. M. Niesley, 170 Broadway, New York City.

Association of Iron and Steel Electrical Engineers, annual convention and Iron and Steel Exposition at Hotel Stevens, Chicago, June 25-29.

Canadian Steel and Power Show at the University of Toronto Arena, Sept. 4-7; Campbell Bradshaw, secretary, 24 Front St., West Toronto, Canada.

National Association of Power Engineers, annual convention at Detroit, Sept. 11-15, and concurrently National Exhibitors' Assn. exhibit; Fred Raven, 417 South Dearborn St., Chicago. New England States Association convention at Hartford, Conn., June 21-23; K. W. Lundberg, secretary. Foot Guard Armory, Hartford. New Jersey State convention at the Plaza Hotel, Journal Square, Jersey City, N. J., June 2-3; T. M. Gray, State Secretary, 46 West 51st St., Bayonne, N. J.

National Board of Boiler and Pressure Vessel Inspectors, meeting at Erie, Pa., June 18-20.

National Electric Light Association, Convention and exhibition, Atlantic City, N. J., June 4-8; A. Jackson Marshall, secretary, 420 Lexington Ave., New York City.

National District Heating Association, annual meeting at Ambassador Hotel, Atlantic City, June 12-15; D. J. Gaskill, sec., 112 West 4th St., Greenville, Ohio.

National Association Practical Refrigerating Engineers, annual convention at Louisville, Kentucky, Nov. 20-23; E. H. Fox, secretary, 5707 West Lake St., Chicago, Ill.

Stoker Manufacturers Association, fall meeting at Greenbrier Hotel, White Sulphur Springs, W. Va., Oct. 22-24.

Universal Craftsmen Council of Engineers, Newark, N. J., Aug. 7-10.

Second Bituminous Coal Conference will be held at Pittsburgh, Nov. 19-22.

PERSONALS

H. H. BAILEY, who for eight years has been superintendent of power production of the Nashville Railway & Light Company, has been transferred to Chattanooga, where he will be superintendent of production for all the power company's stations in Tennesee.

A. G. DAVIS, vice-president of the General Electric Company, has announced the appointment of Charles E. Tullar as manager of the patent department. Mr. Tullar succeeds A. D. Lunt.

H. D. SAVAGE, president of the Dry Quenching Equipment Corporation, announces the election of D. W. Wilson as vice-president and general manager.

LOYALL A. OSBORNE, president of the Westinghouse Electric International Company, was re-elected chairman of

FUEL PRICES

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run, except Pittsburgh gas slack:

Bituminous (Net Tons)	Market Quoting	Price per Ton
Navy Standard...	New York.....	$2.35@$2.60
Kanawha.....	Columbus.....	1.25@ 1.60
Smokeless.....	Cincinnati.....	1.75@ 2.00
Smokeless.....	Chicago.....	1.65@ 2.00
S. E. Kentucky...	Chicago.....	1.35@ 1.75
Steam.....	Pittsburgh.....	1.40@ 1.80
Gas Slack.....	Pittsburgh.....	1.15@ 1.25
Big Seam.....	Birmingham....	1.40@ 1.75
Anthracite (Gross Tons)		
Buckwheat.....	New York.....	$2.75@$3.00
Birdseye.....	New York.....	1.60

FUEL OIL

New York—May 24, industrial use, tank-car lots, 28@34 deg., Baumé, 5c. per gal.; 36@40 deg., furnace, 7c. per gal., f.o.b. Bayonne, N. J.

St. Louis—May 10, tank-car lots, f.o.b. St. Louis, 24@26 deg., $1.52½ per bbl.; 26@28 deg., $1.57½ per bbl.; 28@30 deg., $1.62½ per bbl.; 30@32 deg., $1.67½ per bbl.; 32@36 deg., gas oil, 4.27c. per gal.; 38@40 deg., 4.98c. per gal.

Pittsburgh—May 15, f.o.b. local refinery, 30@34 deg., fuel oil, 5¼c. per gal.; 36@40 deg., 5½c. per gal.

Philadelphia—May 22, 26@30 deg., $2.07 per bbl.; 13@19 deg., $1.22 per bbl.; 22 plus, $1.48@$1.55 per bbl.; 27@30 deg., $2.17 per bbl.

Cincinnati—May 15, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 5c. per gal.; 26@30 deg., 5¼c. per gal.; 30@32 deg., 5.95c. per gal.

Chicago—May 24, tank-car lots, f.o.b. Oklahoma, freight to Chicago, 90c. per bbl.; 22@26 deg., 80@85c. per bbl.; 26@30 deg., 90@95c. per bbl.; 30@32 deg., $1.05 per bbl.

Boston—May 21, tank-car lots, f.o.b. 12@14 deg. Baumé, 4¼c. per gal.; 28@32 deg., 5.65c. per gal.

Dallas—May 19, f.o.b. local refinery, 26@30 deg., $1.35 per bbl.

the National Industrial Conference Board at its twelfth annual meeting on May 15.

O. C. MERRILL, Executive Secretary of the Federal Power Commission, has accepted an invitation to deliver one of the Cyrus Fogg Brackett lectures at Princeton University. He will discuss current phases of the utilities situation in their relation to the water power act.

BUSINESS NOTES

MAGNETIC MANUFACTURING COMPANY, of Milwaukee, has appointed J. H. Phinney as exclusive representative for the eastern part of Michigan, with headquarters at 420 U. S. Mortgage Building, Detroit, to handle the company's complete line of magnetic separation equipment and magnetic clutches for power transmission.

FOOTE BROTHERS GEAR & MACHINE COMPANY announces that it has recently appointed Woodbury & Wheeler, 55 Second St., Portland, Ore., as its representatives in Portland and vicinity and the Cunningham Electric Company, 2123 Pacific Ave., Tacoma, Wash., as representatives in Tacoma and vicinity.

THE WAGNER ELECTRIC CORPORATION announces that E. D. Pike, formerly in charge of Wagner Electric Pacific Coast Service operation, is now manager of the San Francisco branch sales office.

THE ELLIOTT COMPANY, of Jeanette, Pa., announces the appointment of W. E. Widau, until recently sales manager of the condenser department, as manager of the Kansas City district, succeeding F. A. Calnues, who has been transferred to the San Francisco office.

THE DAVIS ENGINEERING CORPORATION, 90 West St., New York City, announces the appointment of Maher Equipment Company, 333 N. Michigan Ave., Chicago, Ill., as its exclusive sales representatives in that territory.

THE KENNEDY VALVE MANUFACTURING COMPANY, of Elmira, N. Y., announces the election of Matthew E. Kennedy as president and treasurer, J. Carroll Kennedy as vice-president and secretary, and Clarence H. Kennedy as vice-president and general sales manager.

THE DAMPNEY COMPANY OF AMERICA, Hyde Park, Boston, Mass., has appointed C. J. Hunter as sales manager of its Philadelphia district with offices in the Philadelphia Bourse Building. He will represent the company in eastern Pennsylvania, southern New Jersey, Delaware, eastern Maryland, the District of Columbia and northern Virginia.

TRADE CATALOGS

HIGH-PRESSURE AIR COMPRESSORS.—The Rex Company, San Francisco, Calif., has just issued Bulletin 150D, devoted to the Rex compressor for use as the auxiliary air compressor in oil-engine plants. This machine consists of a vertical gasoline-engine cylinder and a single- or multi-stage compressor cylinder, a common crankshaft serving both. These units range in capacity from 12 to 130 cu.ft. per min. and are designed for pressures ranging from 250 to 1,500 lb. per sq.in.

INDUSTRIAL HEATER—In catalog No. 45, edition 1, the Clarage Fan Company describes the McCann Harrison heater for industrial buildings. The catalog illustrates both the large central oil- or gas-fired unit, as well as the smaller unit heater types.

COMBUSTION CONTROL—The Automatic Fuel Saving Company has issued a bulletin describing the operation and installation of automatic combustion-control equipment. Typical installations of the control equipment are shown applied to boilers fired with chain-grate stokers, underfeed stokers, and hand-firing.

NEW PLANT CONSTRUCTION

Compiled by the McGraw-Hill Business News Department, which is prepared to furnish a more complete daily service to those who wish it

Ark., Mulberry — City will soon receive bids for the construction of a pumping and filtration plant, etc. Estimated cost $85,000. Dickinson & White, 610 Boyle Bldg., Little Rock, are engineers.

Calif., Independence — Priffman Bros., 5723 South Broadway, Los Angeles, plans the construction of a packing and cold storage plant at Owens Valley. Estimated cost $40,000.

Calif., Los Angeles — A. Weitzman, is having plans prepared for a 12 story hotel and apartment building including steam heating system, elevators, etc. at Beacon and 8th Sts. Estimated cost $750,000. R. C. Yinger, 6362 Hollywood Blvd., is architect.

Calif., Norco — North Corona Land Co., 528 South Hill St., Los Angeles, will build a 67 x 139 ft. power plant, here. R. E. Phillips, 816 West 5th St., Los Angeles, is engineer. Work will be done by day labor.

Calif., Pasadena—Lee Orndorff & Associates, Los Angeles, awarded contract for a 10 story apartment building and 10 story hotel at Colorado St. and Knoll Ave. to Orndorff Construction Co., 247 North Western Ave., Los Angeles. Estimated cost $2,500,000. Steam heating system, electric elevators, etc. will be installed.

Calif., San Jose—Union Ice Co., 354 Pine St., San Francisco, is having plans prepared for the construction of an ice plant, here. Estimated cost $200,000. Private plans.

Calif., Santa Cruz — City awarded contract for the construction of a pumping plant to Fairbanks-Morse Co., Spear and Harrison Sts., San Francisco. Estimated cost $143,960.

Calif., Watsonville—Apple Growers' Cold Storage Co., will build a 300 x 500 ft. ice and cold storage plant by day labor. Estimated cost $250,000. Uttley & Kleindinst, 354 Hobart St., Oakland, are engineers.

Calif., Watsonville—Watsonville Ice & Cold Storage Co., awarded contract for addition to cold storage plant to W. W. Williams Co., 320 Market St., San Francisco. Estimated cost $100,000.

Conn., New Britain—Connecticut Light & Power Co., 111 West Main St., Waterbury, awarded contract for the construction of a power service building on Curtis St. here. to United Engineers & Construction Corp., subsidiary of U.G.I. Contracting Co., Broad and Arch Sts., Philadelphia, Pa. Estimated cost $200,000.

Conn., New London—New York, New Haven & Hartford R.R. Co., Grand Central Terminal, New York, N. Y., plans the construction of a power plant at John Water and Potter Sts. here. Estimated cost $40,000. E. Gabel, New Haven, Ch. Engr.

D. C., Washington—U. S. Coast & Geodetic Survey, 205 New Jersey Ave. S. E., will receive bids until June 22 for the construction of a Diesel electric propelled survey ship, 770 ton displacement. Separate bids for furnishing main propelling machinery, auxiliary machinery, pumps, etc.

Georgia—Industrial Fibre Co., H. Rivitz, Pres., West 98th St. and Walford Ave., Cleveland, O., will receive bids until June 1 for a 330 x 830 ft. factory and power plant here. J. E. Sirrine Co., 309 South Main St., Greenville, S. C., is engineer.

Ill., Chicago — M. R. Plotke, 111 West Washington St., is having sketches made for an 18 story apartment building at 508-512 Diversey Parkway. Estimated cost $1,000,000. Huazagh & Hill, 6 North Michigan Ave., are architects.

Ia., Marshalltown—City is having preliminary plans prepared for waterworks improvements including pumping station, mains, etc. Estimated cost $50,000.

Ky., Paducah—City plans extensions and improvements to power plant. Burns & McDonnell Engineering Co., 401 Interstate Bldg., Kansas City, Mo., are engineers.

La., Alexandria—U. S. Veterans Bureau, L. H. Tripp, Ch. of Construction Div., Washington, D. C., will receive bids until July 5 for the construction of a general hospital including boiler houses, etc., here. Estimated cost $1,500,000.

Md., Baltimore—St. Marys' Roman Catholic Church, c/o Maginnis & Walsh, Statler Bldg., Boston, Archts., awarded contract for a 4 story seminary at Roland and Belvedere Aves. to M. A. Long Co., 10 West Chase St. Estimated cost $2,000,000. Steam heating and ventilation systems, etc. will be installed.

Mass., Ayer—Nashoba Cold Storage Co., c/o Haynes & Mason, 280 Main St., Fitchburg, Archts., is having plans prepared for a 70 x 165 ft. cold storage plant. Estimated cost $50,000.

Mass., Cambridge (Boston P. O.)—City, J. J. Scully, City Hall, Chn., is having plans prepared for the construction of a pumping station on Lake View Ave. and Worthington St. Estimated cost $100,000.

Mass., Foxboro—Dept. of Mental Diseases, is having plans prepared for addition to power house and pumping plant at State Hospital. McLaughlin & Burr, 88 Tremont St., Boston, are engineers.

Mass., Hyde Park (Boston P. O.)—Edison Electric Illuminating Co., 39 Boylston St., Boston, is receiving bids for addition to power sub-station on Fairmount Ave. Estimated cost $40,000.

Mass., Whitman—Brockton Edison Electric Illuminating Co., 42 Main St., Brockton, awarded contract for the construction of a power sub-station here to H. F. Johnson, 248 Belmont St., Brockton. Estimated cost $75,000.

Mass., Wilmington—Town, C. S. Harriman, Comr., awarded contract for the construction of a pumping station to Frankini Bros., Inc., 30 Mystic Ave., Medford. Estimated cost $40,000.

Mich., Detroit—Stott Realty Co., Lincoln Bldg., awarded contract for a 35 story office building at State and Griswold Sts. to W. E. Wood Co., 1805 Ford Bldg. Steam heating system, boilers, elevators, etc. will be installed.

Minn., Minneapolis — Wesley Church Corp., A. H. Maas, Pres., 501 Palace Bldg., plans the construction of a 12 story office building including steam heating system, etc. at Grant St. and Stevens Ave. Estimated cost $850,000. A. B. Boyer, Arcade Bldg., St. Louis, Mo., is architect.

Miss., Millsaps (Jackson P. O.)—Millsaps College, c/o D. M. Key, Pres., is having preliminary plans prepared for a group of college buildings including central heating plant, etc. Total estimated cost $650,000.

Mo., St. Louis—H. C. Folter, et al., 5166 Easton Ave., will build an 11 story apartment building including vapor heating system, etc. at 4615 Lindell Blvd. Estimated cost $850,000. Work will be done by separate contracts under the supervision of D. R. Harrison, 1106 Ambassador Bldg., Archt.

N. J., East Orange—H. F. Clark, 38 Clinton St., Newark, Archt., is receiving bids for a 10 story apartment building including steam heating, ventilation and refrigeration systems, boilers, elevators, etc. at 32 South Munn Ave., here for Advance Holding Co., H. Rothberg, Pres., 24 Branford Pl., Newark. Estimated cost $900,000.

N. J., Paterson — Mountain Ice Co., 51 Newark St., Hoboken, will build an ice plant at 211-219 Lafayette St. Estimated cost $50,000. Private plans. Work will be done by separate contracts.

N. J., Wanaque — North Jersey Dist. Water Supply Comn., 24 Commerce St., Newark, plans the construction of a pumping station. Estimated cost $300,000. Private plans.

N. M., Portales—City voted $31,000 bonds for waterworks improvements including pumping plant, etc. H. Garst, c/o A. & M. College, College Station, Tex., is engineer.

N. Y., Huntington—Dioceses of Brooklyn and R. J. Reilly, Archt., 10 East 41st St., New York, awarded contract for a 7 story seminary here to John Eisel, 18 East 41st St., New York. Estimated cost $2,000,000.

N. Y., New York—B. Gundlach, 597 5th Ave., Archt., is receiving bids for a cold storage plant and warehouse at 240 West 28th St. for Fur Merchants Warehouse Corp., 238 West 28th St. Estimated cost $200,000.

N. Y., New York—Park-Lexington Corp., S. Winters, 14 Wall St., awarded contract for a 25 story hotel at 515 Lexington Ave. to Turner Construction Co., 420 Lexington Ave. Estimated cost $2,800,000.

N. Y., Niagara Falls — Palace Laundry Co., 10th and Pine Sts., will soon receive bids for the construction of a power house. Estimated cost $60,000. R. J. Reidpath, Claremont and Potomac Aves., is engineer.

O., Gallipolis—Dept. of Welfare, J. E. Harper, Dir., Ninth and Oak Sts., will receive bids until June 14 for the construction of an ice and cold stroage plant for Institution for Epileptics. Estimated $45,000.

O., Lorain—Ohio Public Service Co., plans the construction of a new sub-station at Edgewater plant. Estimated cost $450,000.

O., New Philadelphia—Building Commission of Tuscarawas County, J. A. Neff, Clk., will receive bids until June 1, for an infirmary building including refrigerating machinery, laundry equipment, one electric elevator, etc. Estimated cost $180,000. Ronan & Ingleson, 1614½ North High St., Columbus, C. J. Marr, New Philadelphia, are associate architects.

Okla., Welectka—City awarded contract for the construction of a new ice plant, etc. to C. D. Bush. Estimated cost $35,000.

Okla., Yukon—Yukon Mill Co., is having preliminary plans prepared for the construction of a 100 hp. Diesel engine power plant. Estimated cost $100,000.

Tenn., Kingsport — Tennessee Eastern Power Co., Johnson City, has made application to the State Railroad & Public Utilities Commission, Nashville, for authority to construct a power plant and dam on the Holston River here. Estimated cost approximately $5,200,000.

Tex., Brownsville—Valley Bonded Warehouse Co., R. Sethman, is having plans prepared for the construction of a cold storage plant. Estimated cost $250,000. J. A. Taylor, c/o owner, is engineer.

Tex., San Antonio—Interstate Amusement Co., C. Hoblitzelle, Dallas, is receiving bids for the construction of a 14 story theatre and office building here. Estimated cost $2,500,000. J. Eberson, 200 West 57th St., New York, N. Y., is architect.

Wash., Centralia—City Council, is having plans prepared for the construction of a power project. Estimated cost $300,000.

Wash., Ellensburg—City plans extensions and improvements to municipal light plant to increase the capacity to 10,000 kw. Estimated cost $35,000. G. Dunbar, is superintendent.

Wash., Elma—City plans the construction of new waterworks and distribution systems including plant, etc. Estimated cost $25,000.

Ont., Toronto—Canadian Bank of Commerce, King and Jordan Sts., will soon award contract for a 25 story office building including steam heating system, elevators, etc. at King and Jordan Sts. Estimated cost $2,000,000. Darling & Pearson, 2 Leader Lane, are architects.

Ont., Toronto—Toronto Hydro Electric Comn., 225 Yonge St. awarded contract for a 60 x 100 ft. sub-station on Carlaw Ave. to Sullivan & Fried, 81 Victoria St. Estimated cost $150,000.

Equipment Wanted

Ash Handling Equipment—U. S. Veterans' Bureau, Room 791, Arlington Bldg., Washington, D. C., will receive bids until June 12 for ash handling equipment for U. S. Veterans' Hospital, Edward Hines, Jr. at Maywood, Ill.

Boiler and Pump—Bd. of Trustees, Ohio University, Athens, O., G. C. Parks, Secy., will receive bids until June 15 for a 450 hp. steam boiler and boiler feed pump.

Boilers, Engine, Etc. — Weyerhauser Lumber Co., S. Long, Gen. Mgr., Tacoma, Wash., plans to purchase boilers, switching engine, etc. for proposed lumber plant at Flamath Falls, Ore. Estimated cost $500,000.

Generating and Power Equipment, Condenser, Etc.—L. L. Essig, Columbia City, Ind., will receive bids until June 4, for generating and power equipment, condenser, etc.

Generator—Diller Battery Mfg. Co., 3020 Walnut St., Des Moines, Ia., is in the market for a 35 to 40 kw., 125 v., d.c. 325 r.p.m. compound generator.

Generator Sets, Switchgear, Etc.—Dept. of Public Works, Wellington, N. Z., will receive bids until July 17, for two 150 kw. motor generator sets, switchgear, etc.

Pump — Quartermaster, Mitchel Field, Long Island City, N. Y., will receive bids until June 6, for the installation of a motor driven deep well pump with motor at well No. 1.

Pump, Engine, Etc.—F. A. Dupar, Clk, Monrovia, Calif., is receiving bids for furnishing and installing a 2,700 g.p.m. pump with a 160 hp. gas engine.

Pump, Etc.—J. O. Bennett, Acting Mayor and Bd. of Alderman, Troy, Tenn., will receive bids until June 1 for a 250 g.p.m. pump, etc. for proposed waterworks improvements.

Pump, Etc.—O. McIllhenny, Mayor, Lake, Miss., will receive bids until June 7 for deep well pump, etc. for proposed waterworks improvements.

Pump, Etc.—Utilities Commission, London, Ont., prices and catalogs on a 1,400,000 g.p.m. electrically driven pump, 1500 r.p.m. against a 200 ft. head.

Pump, Motor, Etc.—Mayor and Bd. of Aldermen, Boyle, Miss., will receive bids until May 30 for a 175 g.p.m. centrifugal pump and motor, etc. for proposed waterworks improvements.

Pumping Equipment—Bd. of Transportation, 49 Lafayette St., New York, N. Y., will receive bids until June 1 for pumping equipment at 54th, 49th, 40th and 35th Sts. and 8th Ave. on Eighth Ave. Line.

Pumps, Etc.—City of Wilmette, Ill., will receive bids until June 5 for one 1000 and one 5000 g.p.m. electrically driven pumps, etc. for proposed waterworks improvements.

Pumping Equipment—City of Collinston, La., C. B. Mason, Clk., will receive bids until June 12, for furnishing and installing complete pumping equipment, etc. for proposed waterworks improvements.

Transformers, Etc.—A. L. Flint, General Purchasing Officer of the Panama Canal, Washington, D. C., will receive bids until June 8, for transformers, etc.

Industrial Projects

Calif., Los Angeles — STEEL PLANT — A. M. Castle Co., 2064 East 37th St., awarded contract for a 4 story, 75 x 500 ft. plant on 55th St. to Baker Iron Works, 912 North Broadway. Estimated cost $350,000.

Calif., Whittier—OIL WELL SUPPLY FACTORY — H. C. Smith Co., Sorenson Lane and Workman Hill Rd., manufacturers of oil well supplies, awarded contract for the construction of a factory including 70 x 220 ft. machine shop, 60 x 100 ft. welding shop, 60 x 125 ft. warehouse, etc., to Union Iron Works, 5125 Santa Fe Ave., Los Angeles. Estimated cost $90,000.

Ga., Waycross—TEXTILE MILL—Troy Cotton & Woolen Manufacturing, Inc., c/o B. H. Hamilton, Jacksonville, Fla., is having plans prepared for a 1 story, 222 x 1,200 ft .textile mill, here. Estimated cost $1,500,000.

Ill., Chicago — ALEMITE FITTING FACTORY — Bassick Mfg. Co., 2650 North Crawford Ave., awarded contract for masonry, etc. for a 3 story, 81 x 120 ft. factory for the manufacture of alemite fittings for automobiles. Estimated cost $200,000.

Md., Leeds—AUTOMOBILE ASSEMBLY PLANT—General Motors Co., General Motors Bldg., Detroit, Mich., is having plans prepared for a 1 and 3 story, 462 x 481, 161 x 200 and 42 x 208 ft. assembly plant, here. Estimated cost $1,500,000. A. Kahn, Marquette Bldg., Detroit, Mich., is architect.

Mass., Boston—PRODUCE TERMINAL —New York, New Haven & Hartford R.R. Co., South Station, awarded contract for a 2 story produce terminal on Fargo St. to Tredennick-Billings Co., 10 High St. Estimated cost $300,000.

Mass., Medford—VALVE FACTORY—A. F. Curtin Valve Co., 76 Ship Ave., awarded contract for a 1 story factory, to J. A. Ricker, 36 Dudley St.

Mich., Detroit — BODY STORAGE BUILDING — Briggs Mfg. Co., 11631 Mack Ave., awarded contract for a 5 story, 180 x 370 ft. factory for finishing and storage of automobile bodies on Warren Ave. to Otto Misch Co., 159 East Columbia Ave.

N. J., West New York—DISTRIBUTING BUILDING—Public Service Electric & Gas Co., 80 Park Pl., Newark, is having plans prepared for a 2 story, 60 x 200 ft. building at 12th and Jefferson Sts., here. Estimated cost $200,000. Public Service Production Co., 80 Park Pl., Newark, is engineer.

O., Canton — COMPRESSED GAS PLANT — Linde Air Products Co., subsidiary of the Union Carbide & Carbon Co., 30 East 42nd St., New York, N. Y., will soon receive bids for the construction of a plant at 2390 13th St. N. E. Estimated cost $40,000.

O., Columbus—FURNITURE FACTORY —E. M. Hulse & Co., 153 West Fulton St., awarded contract for the construction of a 3 story, 100 x 200 ft. factory on West Goodale St. to E. Elford & Son, 555 Park St. Estimated cost $200,000.

Pa., Pittsburgh — FORGE AND KNIFE PLANT — Heppenstall Forge & Knife Co., 4620 Hatfield St., awarded contract for a 1 story, 100 x 200 ft. addition to plant on Butler St. to Rust Engineering Co., American State Bank Bldg. Estimated cost $50,000.

Ont., Kitchener—PLANING MILL—H. J. Hall & Son, King and Gaukel Sts., is having plans prepared for a 1 story, 100 x 150 ft. planing mill. Estimated cost $60,000. W. H. Schmalz, 129 King St. W., is architect.

Ont., Orillia — TIRE FACTORY — Suspended Air Tires, Ltd., 1189 Bathurst St., plans the construction of a 1 or 2 story, 100 x 100 ft. factory on Atherly Rd. Estimated cost $100,000. Architect and engineer not selected.

Ont., Sandwich — SALT PLANT — Canadian Salt Co. will build a 1 and 2 story addition to plant on Sandwich St. by day labor. Estimated cost $300,000. Private plans.

Ont., Thamesville — WOODWORKING FACTORY—R. T. Gee, Co. Ltd, 173 Dundas St., London, awarded contract for a 1 story, 40 x 120 ft. factory to C. Hubbell. Estimated cost $45,000.

Japan, Tokio—BULB FACTORY—Tokio Electric Co., awarded contract for a 3 story, 120 x 205 ft. electric light bulb factory here to H. K. Ferguson Co., Hanna Bldg., Cleveland, O. Estimated cost $250,000.